Industrial QUALITY CONTROL

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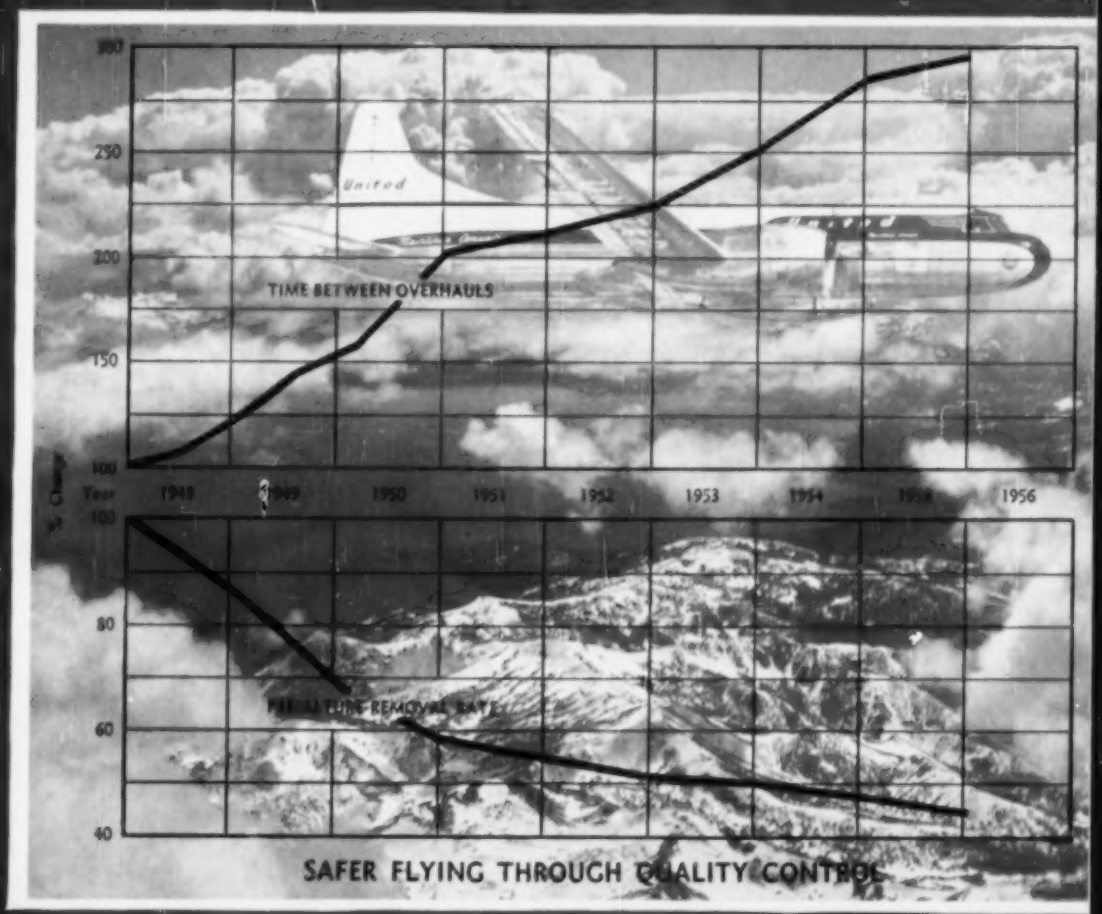

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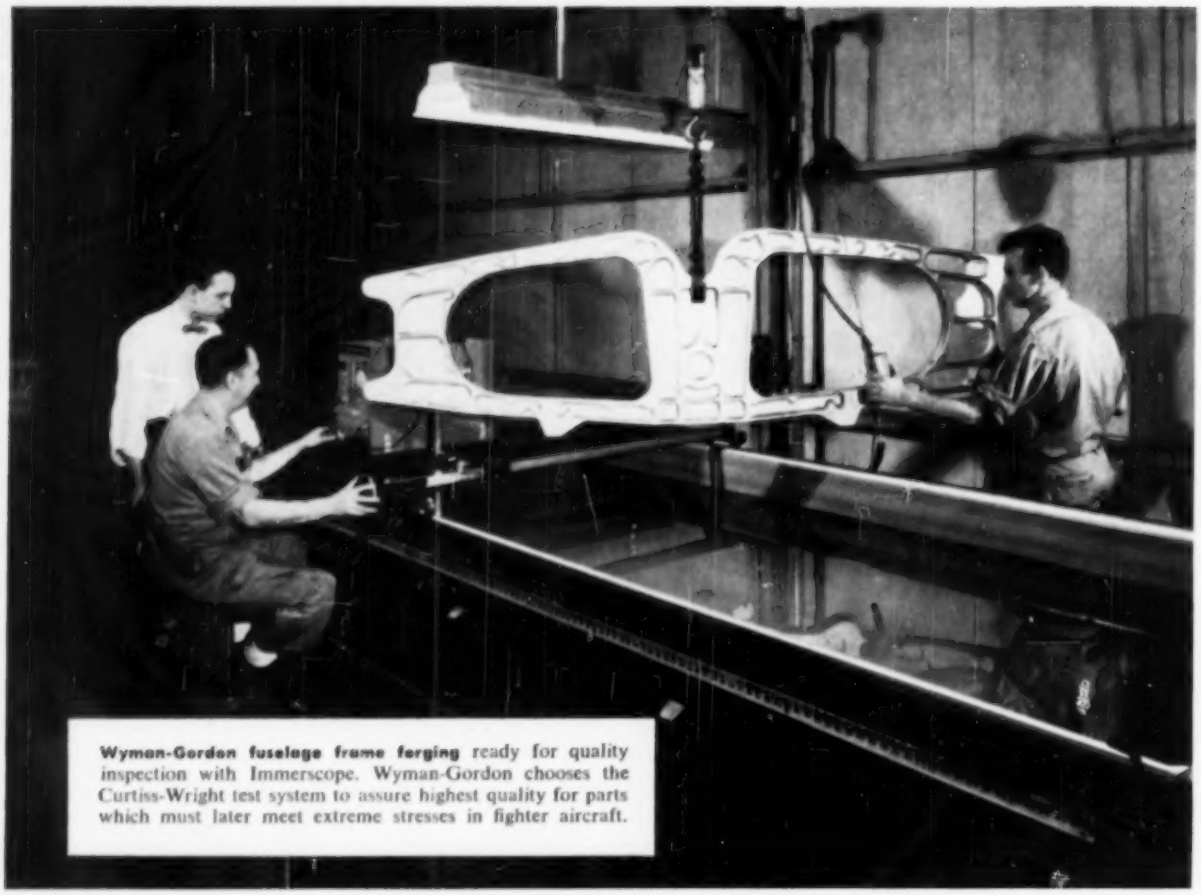

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OUR COVER

This month's cover depicts the fruits of SQC at United Airlines—longer time between overhauls and fewer premature removals. On page 4 is Allan M. Hull's descriptive analysis of how United uses SQC by "Optimizing Maintenance Costs Through Quality Control."

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optimizing maintenance costs through quality control*

ALLAN M. HULL

United Air Lines, Inc.

San Francisco, Calif.

The purpose of this presentation is to consider some of the investment dividends from SQC applications to airline maintenance problems. An airline such as United, which does its own overhaul and maintenance work and operates its own airplanes, is in an advantageous position from the quality control viewpoint for truly we are our own customer—we are our own producer and consumer. In other words, the success or failure of our mechanical operations is contingent upon the quality of our maintenance. For this reason we place a high premium on maintenance facilities and procedures, and technological advances such as quality control and operations research.

Selecting the Equipment

One of the most important steps in an airline operation today is that of selecting the equipment to meet the operational requirements of the airline. Obviously this step is very important for it dictates the maintenance problems with which the airline later will be confronted, and it has a profound influence on the economic stability and competitive position of the airline.

An airline, as any prospective buyer, endeavors to procure its product from a reputable manufacturer—one with a liberal service policy, one that will stand behind its product, and one that will do everything in its power to help the airline solve the maintenance problems that develop. To meet these requirements the manufacturer must have, (1) a top-notch design section, (2) modern laboratory and test equipment and technological know-how employing, among other things, SQC techniques for the proper design and analysis of tests, and (3) modern production facilities and know-how to design and build quality into its product.

New type aircraft frequently incorporate systems and components, or modifications thereof, heretofore untried on existing aircraft. Also there may be an interaction of variables produced by new or different combinations of proven systems and components. Variables, such as power plant installation, airplane-engine-propeller combinations, speed, altitude of flight, and the airfoil design, may produce new problems.

In selecting equipment for airline usage, existing performance data on the same or similar equipment are reviewed and analyzed. Whenever possible, two or more makes, types, or models are compared and differences in installation are considered and studied in view of the proposed installation. The Performance Curve (see Fig. 1) provides a measure of the in-service performance of the system or component in UAL service. It reflects the performance trend of the component and the results of modifications on the part of UAL and the manufacturer and whether or not the manufacturer has cooperated in the improvement of his product.

The Premature Removal Chart (see Fig. 2) is used in conjunction with the performance curve and shows the cause, the number, the time since overhaul relationship, and monthly or seasonal trend of irregularities. It focuses attention on the nature and severity of irregularities, localizing the problem for expedient corrective action.

*Presented at the Western Regional Quality Control Conference, Seattle, Washington, March 18, 1955 and at the San Francisco Bay Area Quality Control Conference, Stanford, California, September 16, 1955.

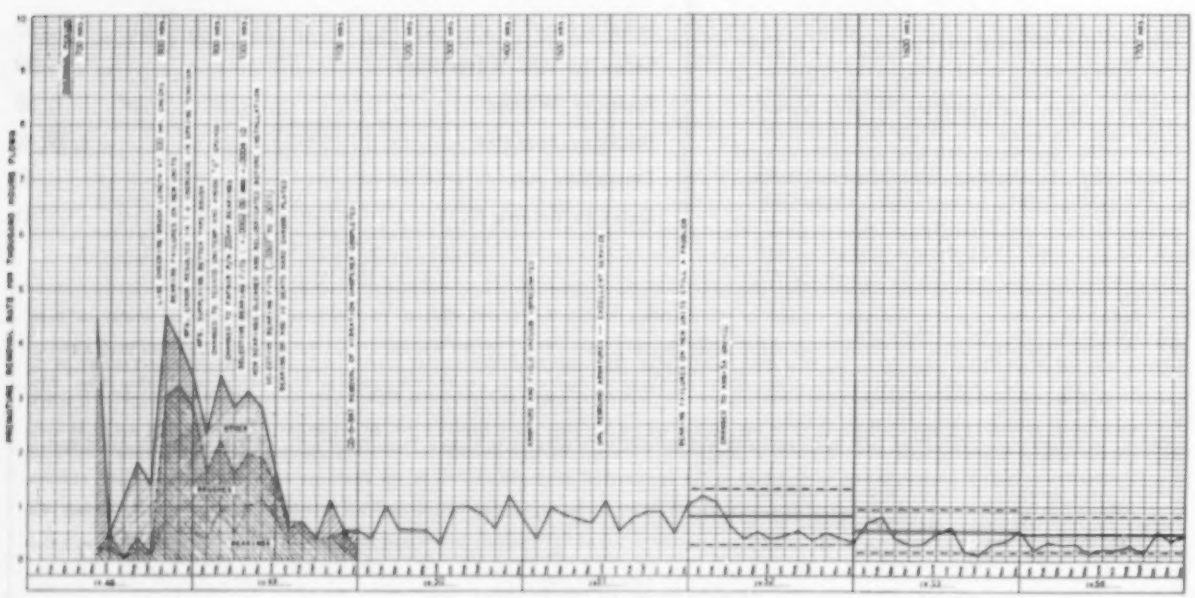

Figure 1—Performance Curve for Generator

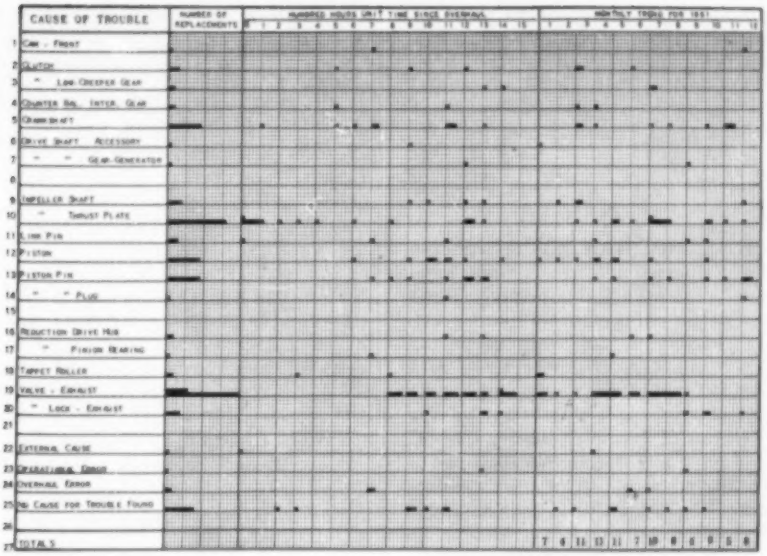

Figure 2—Premature Removal Chart for Engines

The use of statistical methods in the design and analysis of tests is coming into more prominent use for selecting equipment wherein service tests are possible. The airline, as other industries, frequently has been embarrassed because actual service experience did not bear out the optimism generated by the service test. As will be shown in the next section, the statistical approach to test design and analysis has shown great promise of optimizing test results. However, this responsibility should not be left to the airline alone. Whenever possible, the manufacturer should conduct such tests, or cooperate with the airline in conducting the tests. It is in this area that proper design and analysis of tests is a powerful management tool.

Correcting Maintenance Problems

The primary value of SQC to United has been its role in recognizing, localizing, and correcting maintenance problems. The addition of control limits to the performance curve (see Fig. 1) has sharpened its usefulness as a management tool and has removed the "human" element. Development of a nomograph for calculating control limits (see Fig. 3) for our performance curves has reduced the exposure to error, greatly speeded up the process, and has reduced the cost of determining control limits on approximately 1500 components. In developing control limits for our performance curves, we interpreted our problem as a "defects per unit" problem in which the *number of premature removals* was interpreted as *number of defects*, and a *thousand hours flown* as the *unit*.

The formula $\bar{\bar{c}} \pm 2\sqrt{\bar{\bar{c}}/n}$ was used in which $\bar{\bar{c}}$ (c double Bar) is the previous year's average premature removal rate, and n, the number of hours in thousands flown per month by that particular fleet of airplanes. We used 2-σ control limits since we wanted our control limits to give us an advanced warning of impending trouble.

The Premature Removal Chart is used in conjunction with the Performance Curve in analyzing and localizing trouble areas. Since the Premature Removal Chart (see Fig. 2) is maintained on a continuing basis, it frequently indicates trouble areas before the Performance Curve has been posted. The Premature Removal Chart also may indicate a trouble area, a shift in process, or localization of a difficulty that does not result in an out-of-control condition, or corrective action is effected before an out-of-control condition develops. The Performance Curve and Premature Removal Chart are like other SQC charts—they are insurance policies; they tell us how we are doing, attesting to the fact that we are, or are not, in control. Furthermore, when performance is unusually good, they serve as a continual reminder that the overhaul period should be investigated to ascertain whether or not an increase in time between overhauls is warranted.

Figure 2 illustrates how the Premature Removal Chart localizes problems for effective and expedient corrective action. Exhaust Valve failures, item 19, is an example of a problem that is a function of the time between overhauls since all of the failures occurred above 800 hours unit time since overhaul (TSO). A more detailed analysis of the problem showed that the failures were localized in a few cylinder positions. Installation of a new type valve in the critical locations corrected the problem—there were no failures in the last three months of the year. On the other hand the low time failures under item 10, Impeller Thrust Plate, were the result of a change recommended by the manufacturer that did not work out in actual service experience. Note the bunching of failures in July, the month the change was started. The chart clearly localized each problem so that effective corrective action could be taken.

In many cases a so-called "fix" requires considerable modification or change in design. Before the modified or redesigned component is placed in service, it may be desirable to service test the modified

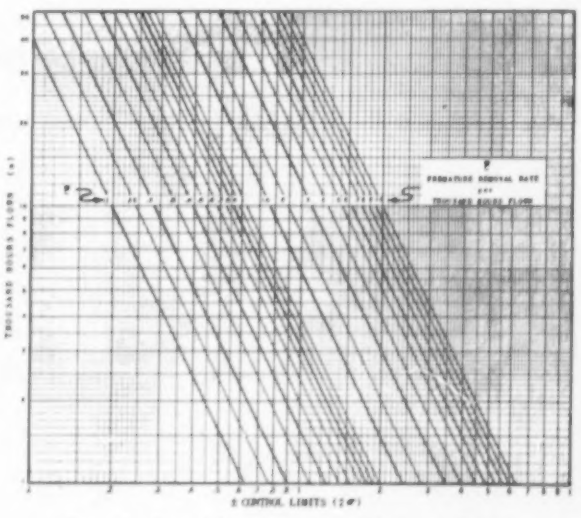

Figure 3—Control Limits for UAL Performance Curves

component and compare its performance with the present product. In other cases two or more design changes are under consideration and it is advisable to evaluate the merits of each. It is in this area that the proper design and analysis of tests is of paramount value.

In one particular maintenance problem, several different configurations of spring designs and tensions, brush sizes, materials and hardness, and surface finish were tested. However, the apparent superiority of certain test configurations over the present configuration were not borne out in actual service experience. In addition there was poor correlation between laboratory, test, and service results. From the test results, the relationship (interaction) among the factors was vague. Since there were two components per engine it was easy to design a test to eliminate the environmental factors and to reduce bias to a minimum. Analysis of variance studies were made (see Table I) and early in the course of the test, which paired a control and test unit, it became apparent that engines were a significant variable in the process, a variable that had not been taken into account in previous tests. This factor accounted for the poor correlation between test results and service experience.

Determining the Optimum Overhaul Period

Since the dawn of the machine age, maintenance personnel have been searching for a better method for determining the optimum service, inspection, or overhaul period for equipment. If performance data are available for analysis, the method of analysis represented by the "Overhaul Period Analysis Curve" in Fig. 4 and 5 supplies the answer to this problem. In aircraft maintenance this mortality or actuarial method of analysis has proven its value as a tool for determining the optimum overhaul period of aircraft components.

The Overhaul Period Analysis Curve expresses performance on a mortality or actuarial basis, using Thousand Hours Flown per Premature Removal as the base or measure of performance. The Overhaul Period Analysis Curve answers two questions commonly asked when analyzing the performance of a component: (1) What is the performance in each Time Since Overhaul (TSO) Bracket (age group or cell) of the overhaul period? (2) When should the component be overhauled for optimum performance?

The *non-cumulative curve* (see broken line Fig. 4) answers the first question. It shows the mortality rate in each TSO bracket (age group or cell) of the overhaul period. The TSO brackets are represented on the abscissa (horizontal scale) of the curve in Hundred Hours Unit TSO (Time Since Overhaul). By previous agreement performance for the cell interval is plotted on the right-hand margin of the cell. The experience in each TSO bracket is found by dividing the total hours operated by all units (the exposure) in the TSO bracket by the number of premature removals (the experience) in the TSO bracket.

TABLE I—Analysis of Variance for Distributor Test

BATCH (Engine)	TREATMENT: TEST	TREATMENT: CONTROL	B
1	751	751	1502
2	751	*393	1144
3	751	751	1502
4	791	*491	1282
5	* 85	*217	302
6	712	712	1424
7	791	791	1582
8	791	*160	951
9	471	*373	844
10	650	*394	1044
11	650	750	1400
12	447	*269	716
T =	7641	6052	13,693 = G

G = Grand Total
T = Total for each Treatment
t = Number of Treatments
B = Total for each Batch
b = Number of Batches
X = Individual Values

t = 2 b = 12

* In-Service Failure

Note: Figures represent hours flown. Data were accumulated prior to conclusion of test for preliminary evaluation and analysis.

(1). Correction Factor (CF) $= \frac{G^2}{bt} = \frac{13.693^2}{12 \times 2} = \frac{187,496,249}{24} = 7,812,427$

(2). Total Squares $= \Sigma X^2 - CF = 751^2 + 393^2 + \ldots\ldots + 269^2 - CF = 9,097,937 - 7,812,427 = 1,195,510$

(3). Block Squares $= \frac{\Sigma B^2}{t} - CF = \frac{1502^2 + 1144^2 + \ldots\ldots + 716^2}{2} - CF = \frac{17,265,301}{2} - 7,812,427 = 820,223$

(4). Treatment Squares $= \frac{\Sigma T^2}{b} - CF = \frac{7641^2 + 6052^2}{12} - CF = 7,917,632 - 7,812,427 = 105,205$

(5). Error Squares $= (2) - (3) - (4) = 1,195,510 - 820,223 - 105,205 = 270,082$

(6).

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	TABLE VALUES 5%	TABLE VALUES 1%	CONCLUSION
TREATMENT	105,205	(t−1) 2−1=1	105,205	4.28	4.84	9.65	No significant difference
BLOCK	820,223	(b−1) 12−1=11	74,566	3.04	2.82	4.46	Significant difference
RESIDUAL ERROR	270,082	(t−1)(b−1) 1×11=11	24,553				

(7). $\frac{\text{Treatment Mean Square}}{\text{Error Mean Square}} = \frac{105,205}{24,553} = 4.28$

$\frac{\text{Block Mean Square}}{\text{Error Mean Square}} = \frac{74,566}{24,553} = 3.04$

The *cumulative curve* (solid line) answers the second question. It shows the cumulative experience at any given point in the overhaul period. It shows the performance of all units from zero time (overhaul or new) to each point in the overhaul period represented on the abscissa. Performance at each point in the overhaul period is calculated by dividing the total hours flown by all units to that point in the overhaul period by the total premature removals during the same period. The result is the hours flown per premature removal to that point in the overhaul period. In other words, if the sample taken is a representative sample, and represents the process or product being produced, each point on this curve represents the performance that can be expected if the unit is overhauled at that particular point in the overhaul period. For optimum performance, the component must be overhauled at the highest point on the cumulative curve. If this point occurs at the end of the overhaul period, a further increase in overhaul time may be warranted. A positive slope to the curve may be an indication that the overhaul period should be increased, a negative slope that the overhaul period should be reduced. The final decision is based on the safety and economic factors involved.

Figure 4 covers an example where the overhaul period was too long. In this case the cumulative curve (solid line) had a positive slope during the first 5000 hours of the overhaul period. However, after 5000 hours the slope of the curve changed and all points on the non-cumulative curve fell below the cumulative curve. This characteristic indicates that the overhaul period is too long and for optimum performance should be reduced to the highest point in the cumulative curve. Performance during the first 5000 hours of the overhaul period averaged 17,670 hours per premature removal, while performance in the 5000 to 7000 hour TSO bracket dropped to 6237 hours per premature removal, roughly a three to one ratio.

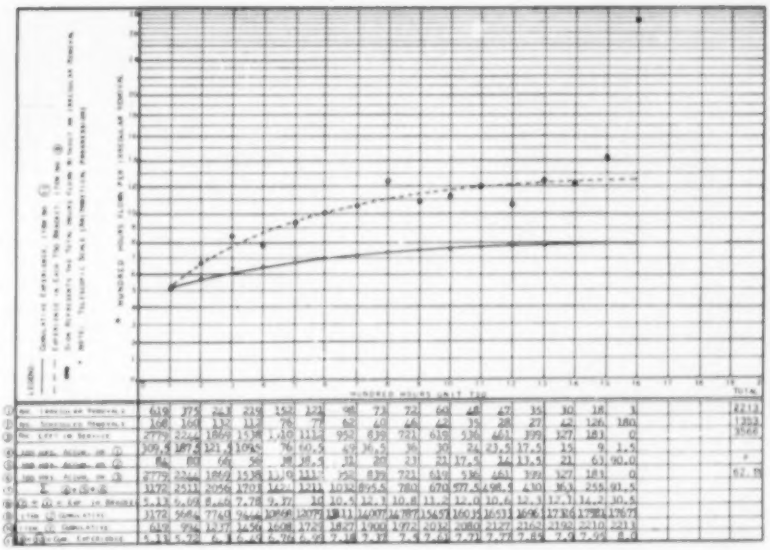

Figure 5—Overhaul Period Analysis Curve for Electronic Equipment

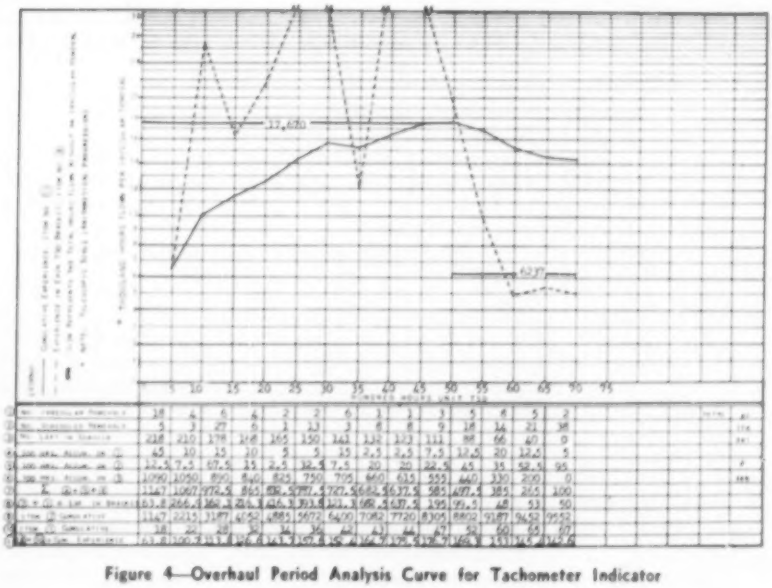

Figure 4—Overhaul Period Analysis Curve for Tachometer Indicator

The value of the Overhaul Period Analysis Curve as a management tool for solving mortality and actuarial problems, and problems of a similar nature, is growing in importance and scope. One of our engineers found it a very useful tool for evaluating and comparing the performance of two or more groups of test units, following them through the course of the service test. For the most part he preferred its use to other statistical methods for evaluating test results. Other applications of the Overhaul Period Analysis Curve include its use in determining the optimum reconditioning, readjustment, sharpening, etc., period on production machines. The performance (mortality) of a component during any portion of its overhaul period can be calculated by dividing the total time operated by all components during the period by the number of premature removals during the same period. The percentage of units remaining in service at any given point in the overhaul period is found by dividing the number left in service at the end of the period by the total units in the sample. The average time operated by all units in the sample is found by dividing the total time operated by all units (the right-hand figure in item 9) by the total units in the sample.

A survey of the performance of electronic equipment used on our DC-6 and DC-6B aircraft showed that the mortality rate was highest immediately after overhaul (see Fig. 5), and that the mortality rate, or probability of failure, decreased as

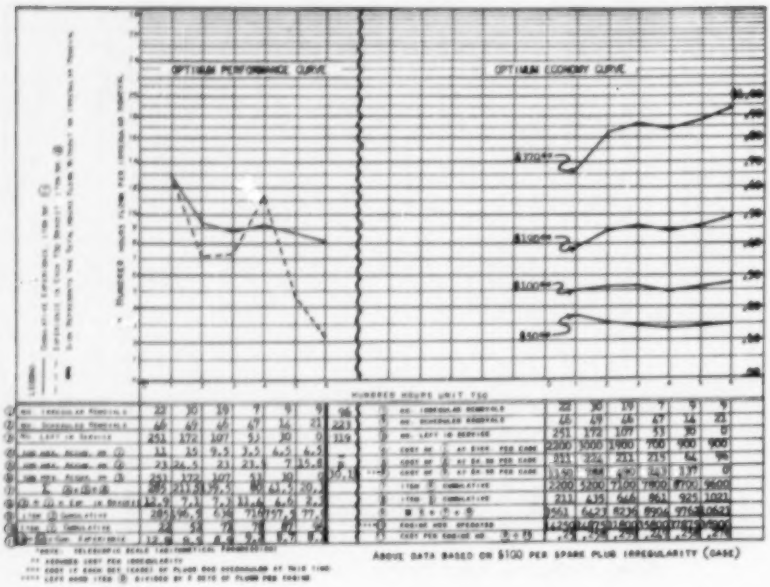

Figure 6—Optimum Performance and Economy Curves for Spark Plugs

the time since overhaul increased. Our analysis showed that arbitrarily overhauling these components at a predetermined overhaul period, i.e. at plane overhaul, reduced rather than improved the reliability of our electronic equipment—we were "overmaintaining" our equipment; this is preventive maintenance in reverse. Overmaintaining our electronic equipment has not only resulted in a loss of operational reliability, but also has resulted in a waste of manpower.

Another application of the Overhaul Period Analysis Curve is its use in determining the most economical overhaul period, the optimum economy period. In this application (see Fig. 6) each premature removal was priced to show the cost of the irregularity, and the calculations are completed to show the operating cost per hour if the component is overhauled at any of the pre-selected points in the overhaul period. In this example the cost of premature removals was assigned different values to illustrate the importance of reliable cost data in decision making.

The Overhaul Period Analysis Curve has proved its value as a problem solving technique in many ways, and we are continuing to find new and varied applications. However, I believe its greatest potential lies in its use as a quality control tool for optimizing inspection, service check, and overhaul periods. By changing the unit of measure from hours to miles, RPMs, cycles, days, months, etc., its application can be extended to many types of problem solving situations, particularly those concerned with maintenance problems in industry. Furthermore, the irregularities can be assigned weighted defects or demerits, cost figures, etc., so that the problem can be visualized in its true perspective. This method of analysis brings the problem into focus so that a wide variety of questions can be answered in arriving at a management decision.

Conclusion

Overhaul period time extensions are one measure of the benefits accrued as a result of our quality control (SQC) application to maintenance problems, which alone for 1954 exceeded one million dollars. Another measure is the reduction in the premature removal rate. However, these gains are not due to the SQC applications in one group alone. Since Maintenance Analysis is responsible for determining the optimum overhaul time, substantiating and processing same with the CAA, the SQC applications discussed herein provide a means for accurately evaluating maintenance trends and determining when an overhaul time extension is warranted. In other words, SQC provides the tools for improving maintenance, recognizing, and capitalizing on good service experience. Overhaul time extensions are, in the final anlysis, the results of many activities within United Air Lines, the result of the interaction of many factors such as training, experience, design changes, improved work facilities, methods and procedures, operations research, and quality control—to mention but a few.

However, Fig. 7 is the best index of the results, for truly "the proof of the pudding is in the eating." During the eight years our DC-6 aircraft have been in service the premature removal rate per thousand plane hours flown has been reduced to less than 50 percent of the rate during its first year of operation as a new airplane. During this same period the overhaul time has been increased nearly 300 percent—a six-fold gain. We believe this is a very fine record, one in which we can take justifiable pride.

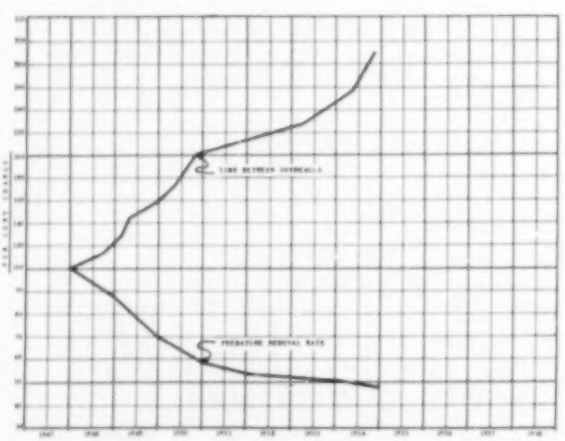

Figure 7—DC-6 Aircraft Performance vs Time Between Overhauls

The Eyes Have It—— At Convair

THERESE
GRAF
TANALSKI

Convair, A Division of General Dynamics Corp., San Diego, Calif.

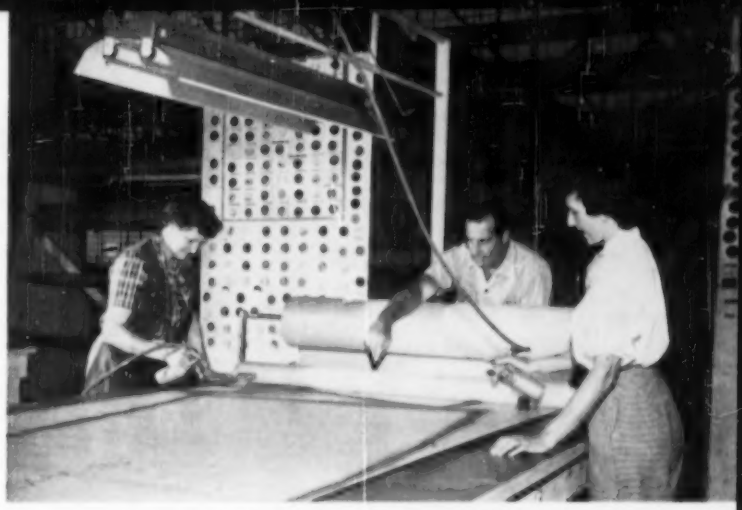

Figure 1—Careful Cutting Eliminates Defective Areas

With color a prominent factor in product appeal, nearly all manufacturers encounter color problems in packaging or finish. In the aircraft industry finishes are designed and executed to the individual customer's taste. Whatever the variety of shades or tints desired, the contractor supplies them, for one ship or one hundred. Thus a diversity of colored materials continually is purchased, stocked and processed. Unless well thought out and understood methods of color evaluation and control are practiced, mistakes would eat up profits and customer relations would suffer.

Employing an original test for color discrimination acuity, Convair carefully selects and certifies inspectors responsible for color matching. Comparing materials or parts to engineering standard samples under special light, these inspectors assure a high level of finished product quality while effecting considerable savings. Off-colors are eliminated at receiving and shade match-controlled by inspection before and after cutting. (An example of this is pictorially described in Fig. 1. By careful cutting, defective areas are eliminated. The lead man points out cutting template; worker stencils panel fabric with spray gun to define part for cutting. After cutting, related pieces are inspected for shade match and quality and wrapped in ship lot kit which is stocked until schedule calls for assembly.) For this company, selective placement of personnel has proven a more practical tool in color control than electronic instrumentation methods, sometimes used in industry. Convair previously investigated photometric tristimulus colorimetry and concluded that—in this case—the well trained eye is quicker, more accurate and more reliable than the instrument.

Background of the Problem

Color matching problems involve several elements: lighting, gloss, dye combination characteristics, color vision of the viewer, and fading or soiling of standard samples. Practical difficulties include inability of fabric manufacturers to produce successive lots conforming exactly to a standard. In the fabric trade, a "commercial tolerance," however this term may be interpreted, is the rule. The Munsell Color Foundation defines approximate color match tolerances in National Bureau of Standards units as follows: A-3, AA-2, and AAA-1, with Munsell hue, value and chroma figures to match. However, few vendors apply this mathematical expression of tolerance.

It is evident that critical control of colored materials at receiving beyond what the vendor can obtain within his own plant, fails to improve the situation. The sensible approach to color matching begins with a firm understanding about acceptable variations on finished material orders. Secondly, "ship lot" control of fabrics and trim is necessary. Finally, shop and inspection must be instructed in what quality level can reasonably be expected. (See Fig. 2.)

Experience with Instruments

At one time it was assumed that a "color-matching" machine would answer all these questions. Actually no such device, suitable for use under shop conditions, has yet been marketed. Instruments of this type, essentially research tools, are applicable in industry only to uncomplicated situations in which a "yes-or-no" answer is sought.

For each model, Convair handles about 20 fabric colors as well as harmonizing paints and plastic trim. Predominately greys, tans, and creams, the basic colors are mixtures of various dyes and may be definitely off-color as well as too pale or too dark.

Percent reflectance readings of available instruments are meaningless by themselves as a color definition. Color difference from a standard is the information needed. For each sample in question the reflectance values (with blue, green and amber filters) must be substituted in a rather complicated formula.*

If the volume of goods to be examined daily warranted a continuous color inspection function, services of a technical computer or utilization of the I.B.M. facility for solution of the color difference equation might be justified. But at Convair, one trained inspector with good color vision is rated more efficient than a combination of instrument operator plus mathematician. Depending on color standards and the inspector's judgment, we must then endeavor to channel only the worker with keen color sense into this function.

Original Psychological Research Needed

Before the Color Discrimination Acuity Test was conceived, commercially available color tests and pertinent technical literature were examined. Academic

*See U.S. Dept. of Commerce, Nat'l Bureau of Standards Circular C429, "Photoelectric Tristimulus Colorimetry with Three Filters," by R. S. Hunter.

Figure 2—Use of Standard Samples in Shop

authorities were consulted. Apparently no precedent had been established for a measurement of color sense. Beyond tests for color blindness (Ishihara) and color identification (the Army yarn test) psychologists have no appraisal of a person's ability to discriminate between subtle differences in color and shade. Since the hue we see is a subjective matter, no objective standard for this can exist. What one calls brown may be to another a muddy blue. Gloss, too, affects our reaction, since shiny surfaces appear lighter to the eye.

In devising the test procedure we sought: (1) individual administration under standard conditions of presentation and lighting; (2) use of materials easily replaceable as they become worn or soiled; (3) close relation of test elements to materials handled on the job, providing a "job replica" test; and (4) introduction of a time limitation to give an advantage to the superior without handicapping the average subject. Though not mandatory for an aptitude test, these requirements were dictated by anticipated test usage, time and facilities provided. For example, while group presentation is usually more reliable, the individual approach was preferred. Adaptation to groups can be made later if desired.

Plan and Scoring of the Test

Administration of the Convair test takes 20 minutes, of which the subject's operating time is six minutes. The first section (of three) involves arranging eight packets of color series cards from light to dark. Some are off-shade, making this an exercise of instinctive reaction rather than deliberation—within the time allowed. Relative placement of the cards is determined exactly by spectrophotometer measurement of reflectance values. In the second part (Fig. 3) the subject is handed six painted panels, each to be laid down without hesitation opposite its duplicate, previously placed on the table by the interviewer. Slightly varying greys, these panels are quite difficult to place within the 20 seconds allowed. The average accomplishment is 59 percent. The third part of the test (Fig. 4) involves coordination of match systems in low-saturation colors (tans, greys). The subject chooses from an assortment of fabrics and paint panels best matching five different plastic strip colors. Three minutes is allowed for arrangement of choices. The level of difficulty is indicated by the average accomplishment of 40 percent.

The subject and interviewer sit facing each other at a table covered with neutral-colored paper. Fluorescent overhead lighting is used since this is typical of better lighting conditions in the shop and is readily available. Using a wristwatch with a second hand the interviewer unobtrusively checks the time.

In Part I of the test, one point is allowed for each correct placement. In the other two parts, weighted scoring is used, the more difficult choices meriting greater point allowance. Part scores are not significant as such, since each section of the test is designed to check a separate facet of the ability to judge color.

Proof and Use

Initial validation studies involved administration of the test to a random group and retesting for accumulation of reliability data. When changes in test elements or procedure appeared desirable, further tests were given. Derivation of the scoring system was statistical information on performance of the experimental group. Here was a practical exercise in statistical procedures.

Although a high reliability (82 percent) was verified for the test, rigid classification of scores is unwarranted. Subjects' performances are reported above or below average or as quartile ratings. One retest is allowed. At present, workers in the top or fourth quartile only are certified for color work. Since validity, as distinguished from reliability, is evaluated by comparing each worker's score with his individual performance on the job, this qualification is obtained over a period of time from supervisors' observations.

Policy planners naturally appreciate color discrimination acuity to be just one factor in effective color control inspection. Aside from test performance, other desirable traits common to all valuable workers are certainly considered. However, after a year's experience with the Color Discrimination Acuity Test, Convair quality control reports a vital feeling of personal responsibility on the part of the certified color and finish inspector and fewer time-consuming disagreements about color matching. That this test has more than paid for itself is definitely agreed.

Figure 3—Test Part II—Color Discrimination Acuity

Figure 4—Test Part III—Key Color Coordination

Quality Control, More Than a Paper Empire

RALPH D. HUMPHRIES

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The purpose of this presentation is to discuss "the application of quality control without developing a paper empire." Many organizations after planning and building a quality control system have found that they are spending a lot of hours accumulating data. Suddenly they realize that they have developed reams of charts, summaries and reports. They get so many varieties of reports that it becomes impossible to review everything and soon the reports end in the waste basket.

Let us consider what quality control means. I like to think of quality control as stated in this definition:

> Quality control is the control of quality at some predetermined level. In any manufacturing organization it is necessary to produce parts and assemblies economically and yet meet competitive quality requirements from a production standpoint. The important thing is not, "How many parts can be produced?" but "How many quality parts can be produced at an economical level of production?"

With this definition in mind, what do we need in a good quality control system?

- A simple, economical, and accurate method for the accumulation of data.
- The analysis of the data to determine where trouble exists, which is the most important, and where the greatest emphasis on corrective action should be placed.
- A method to inform those who can and will take corrective action.

The techniques of statistical quality control are quite adaptable to these three steps. Some have expected these techniques to become a cure-all or a solution to all problems. They should be considered only as tools. The scope of usefulness of tools of this type, like any other, can be over-emphasized and, like other tools, when the cost of the tools plus their cost of operation exceeds the value received, the tools are soon shoved to one side.

The cost of developing and maintaining a quality control system is often a touchy subject. In reality, cost is by and large generated by the objective evidence created for quality assurance. In a quality control system, some records and forms will be used to satisfy various contractual and government requirements. I hesitate to elaborate on projected cost, but rather, consider the savings that may be created by utilizing the natural services that are available.

Process records, receiving reports, laboratory analysis, inspection records and customer's complaint re-

Figure 1—Front and Back View of an Inspection Procedure Card

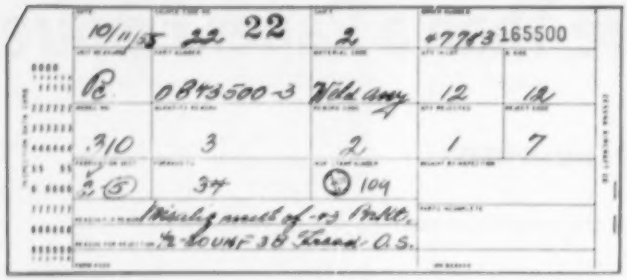


Figure 2

ports are all a basis for quality analysis. If the data are accumulated accurately and properly arranged, they will reveal valuable information. Adequate evaluation of existing records may indicate unnecessary requirements or the need for additional ones. Sometimes the criticism of the forms and paper used is unjustly exaggerated. Often the misuse or overuse in one phase of operation unfortunately handicaps another.

Now, let us consider our job. How elaborate should our system be?

We at Cessna feel that it is quite easy to build up what is better known as a "paper empire" in trying to develop a good quality control system. When the statistical approach is first introduced, people are usually skeptical of its value. When it is finally applied to a job and the results are very convincing, the natural thing is to suggest its use on every job. This soon leads to an accumulation of excessive data which cannot be utilized and is often times not necessary.

We have studied many systems used by other manufacturers and governmental services before arriving at a system which we now use. A number of our forms and techniques are not original. We are very grateful to the many cooperative and helpful friends who have so generously shared their ideas.

We believe that for a quality control system to be successful it is necessary that management have a definite desire to produce a quality product. Management operating with a rigid quality policy will demand that all employees responsible for producing quality keep a close watch on all deviations and rejections. This is a prime factor in developing analyses and reports. The value of a report is determined by the value received from its use.

In the first step of our system to collect and accumulate data on a particular operation, a lot of special forms and procedures are not necessarily required. If a careful study is made, perhaps one form may be sufficient for recording data on all attributes inspection such as outside production, standard parts receiving, in-plant fabrication, or subassembly.

To illustrate where conservative thinking may reduce excessive paper work, let us review a few examples.

In Fig. 1 we have developed an inspection procedure card used by the detail inspector as a guide for sampling and inspection instruction. It is also used as a file record for all orders received. This form is versatile so that it may be used in all departments. Accumulated information can be summarized on the card at any time. However, we have found that an easier way to summarize the results is through IBM tabulation.

The most versatile form used is the IBM card (see Fig. 2). For each order or lot of parts inspected, a card is filled out with the information necessary to tabulate a summary as required. This card is developed for use in any department of production. Code numbers are used to identify vendors, shop discrepancies, materials, etc. In developing a code, it is advisable to coordinate with all other departments which may use the same code. For example, our material code is used by Purchasing, Stores, Production, Planning, Accounting, and Inspection. The vendor is used by

TABLE I—Rejection and Rework Code Numbers

1. *Wrong Raw Material:* type or thickness; tensile strength and chemical analysis unsatisfactory; no certification; certification not available; blisters; flaws.
2. *Dimensional Error:* too large or short; too wide or narrow; too thick or thin; too deep or shallow; oversize or undersize.
3. *Forming Error:* misformed flanges; formed backwards; joggled wrong; dimpled wrong.
4. *Drilling and Reaming Error:* out of line; misaligned; oversize; undersize; rough; elongated; tapered holes omitted; double drilled; drill runs; drill marks; drilled in error.
5. *Countersinks and Spot Faces:* too deep or shallow; elongated; rough surface; cocked; countersunk or spot faced in error.
6. *Machining Error:* undercut; cuts not parallel; off in concentricity; not perpendicular; finish rough or wavy.
7. *Threads:* wrong type; rough; out tolerance; not concentric; tapered; threaded in error.
8. *Welding and Brazing:* wrong type weld or braze; operation in error; insufficient penetration; pin holes and flaws; undercuts and burnt material.
9. *Protective Treatment:* defective plating; anodize; iridite; paint; primer; unprotected; operation in error.
10. *Corroded:* pitted; porous; cavities; rusted; stained.
11. *Operations:* missed; reversed; wrong; incomplete.
12. *Trimmed:* rough trim; cutouts in wrong location; undersize and oversize; trimmed in error.
13. *Oil Canned:* buckled; bowed; twisted.
14. *Material Condition:* scratches; rough or wavy surface; torn; dented; cracked; scribe marks; handling damage; blisters; delaminations; won't harden; stains; proof load low.
15. *Heat Treat and Age Harden:* operation incomplete; not within specification; heat treated too many times; no test coupons; operation in error.
16. *Contour:* wrong contour; under; over; wavy.
17. *Identification:* wrong number; number poorly applied; wrong method of identification; identification obliterated; damaged by identification.
18. *Rivets:* bad; missing; wrong pattern; wrong size or type; too many; incomplete; not in shear.
19. *Assembled:* wrong per specification; parts missing; improperly located; out line; with wrong bolts, screws, nuts, and bearings; defective staking; omitted parts; failed functional test.
20. *Riveting Damage:* set marks; bar marks; dings; gouges.
21. *Bad Repair:* unauthorized repair; cannot be or was not repaired per disposition.
22. *Electrical Error:* damaged wire instruments and units; will not operate; burnt out in test; not per specification; not properly insulated and installed.
23. *Misfits:* tight assembly; overlaps of tolerances; gaps; misaligned; bad appearance; ruined in trying to assemble.
24. *Planning Operation:* left out operation; in wrong sequence; different than specification; not made for correct serial; too many ordered.
25. *Engineering Error:* drafting error; cannot be assembled; will not function; failed under load; cannot be made per specification; redesigned.
26. *Tooling Error:* inadequate tools; no tools available; tools in error; parts made by tooling department; tools not per specification.
27. *Purchasing:* purchased wrong parts; error on purchase order; purchased from unapproved vendor.
28. *Inspection:* bought parts in error; ruined the parts by inspection.
29. *Handling:* delivered to wrong place; bypassed departments; damaged in transit; not properly protected in transit; improperly stacked.

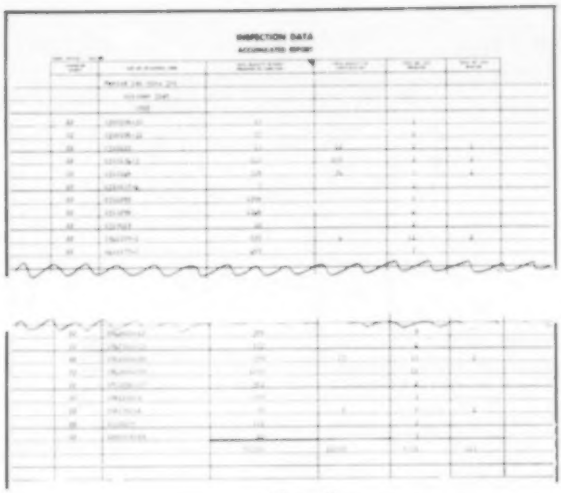


Figure 3

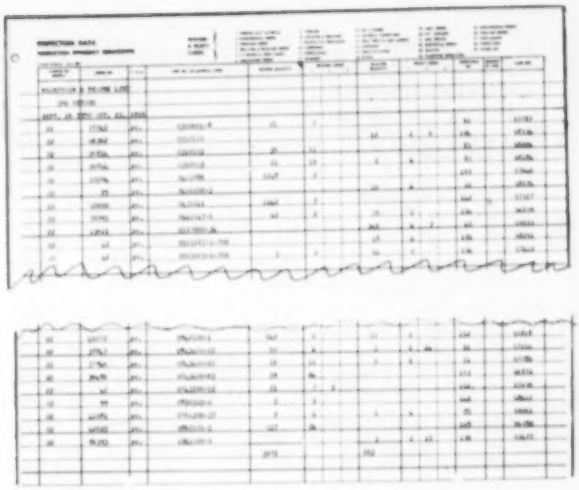


Figure 4

Purchasing, Accounting, and Inspection. The rejection code should be one which is easy to use and to interpret. In a quality-minded plant, the supervision usually is aware of the errors. They may employ various ways of keeping informed of the mistakes being made. In our shops, the foreman who is responsible for all production in each department requests that he be allowed to sign all rejection tags and rework orders. Now, due to the jumble and variety of discrepancies throughout the day, he needs a tally or recap over a period of time to determine how many like parts with like discrepancies are being rejected, and in what area the greatest degree of corrective action is needed. It is for this purpose that a code is developed —one that reduces numerous detail characteristics into a few broad-term characteristics. (See Table I.)

Once a month all cards from each department are tabulated into two reports. One tabulation shows the total parts presented to inspection, total parts rejected, quantity of lots presented and quantity of lots rejected on each part number in a department or from a vendor. This is cumulative from month-to-month for six months.

From this report, the percentage of defective lots and parts can be readily calculated and charted for each part number or each department, by dropping the totals for the oldest month when adding the totals of a new month, the accumulative figures show a trend. (See Fig. 3.)

A second tabulation shows disposition of all defective lots, listing for each department or vendor the date, quantity rejected, reason for rejec-

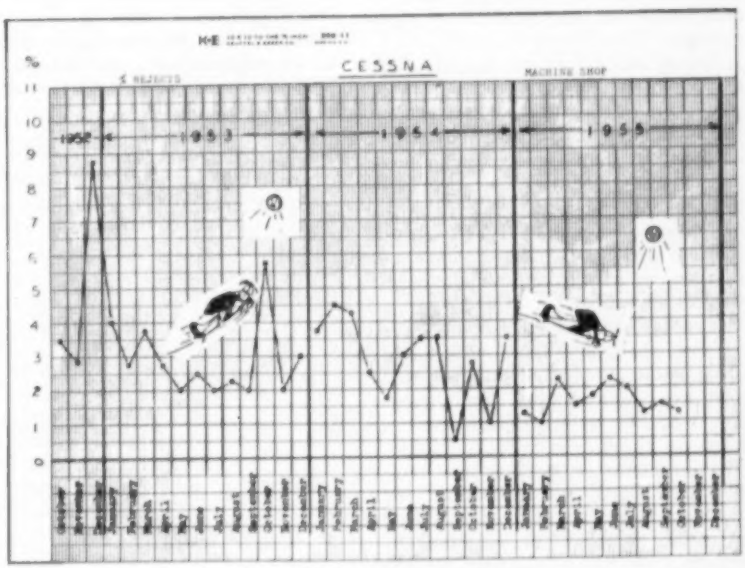


Figure 5—Monthly Report Chart

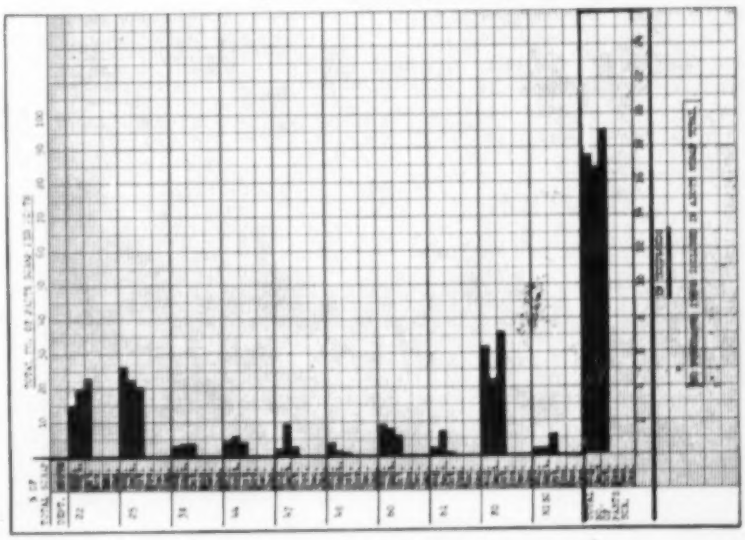


Figure 6—Monthly Report Chart

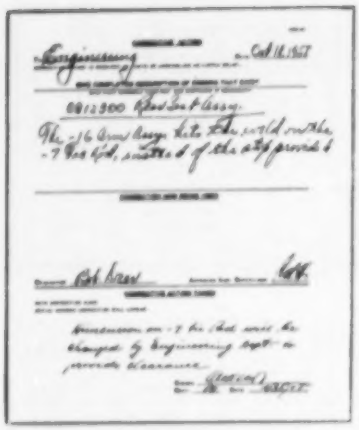


Figure 7

tion, quantity returned for rework and reason for rework for each part number. (See Fig. 4.)

These tabulations are furnished to the foreman, supervisors and other interested parties so they may study the report and take corrective action as required.

The quality control section coordinates with the production departments in developing charts and summaries which may be needed to further aid in developing adequate corrective action.

Now let us review what we have accomplished. We have accumuated data by a simple, economical and accurate method and summarized the data into a form which can be used by those who control quality. The summary segregates the troublesome spots by grouping the characteristics which need the most attention. We have coordinated our efforts with the production department, becoming a service department to the quality producing department.

Depending on the results, we may see the need for a more detailed analysis to determine the cause of the recurring discrepancies on one particular part or operation and to determine the variation. In such cases the $\bar{X}$,R and c charts are used. Here again it is important to keep the procedure and forms simple. They should be used only on those jobs where additional information is required. Too many unnecessary applications lead to lack of interest. Quality control charting creates a psychological effect which alone develops a quality attitude. This effect is rapidly minimized when charts are placed on jobs that are not troublesome or where the charting is not needed to determine the answers.

To encourage corrections by the production departments, we developed a shop scrap tag. This tag is

Figure 8

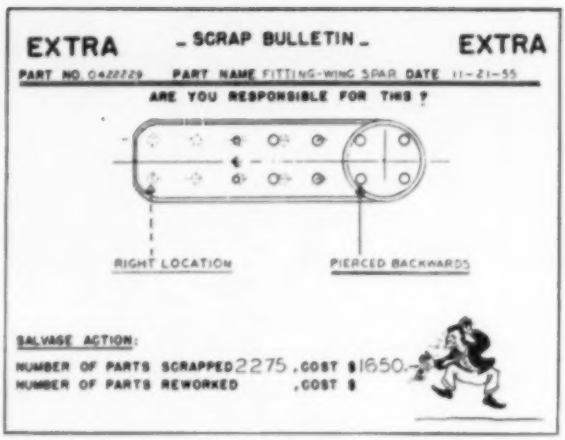


Figure 9

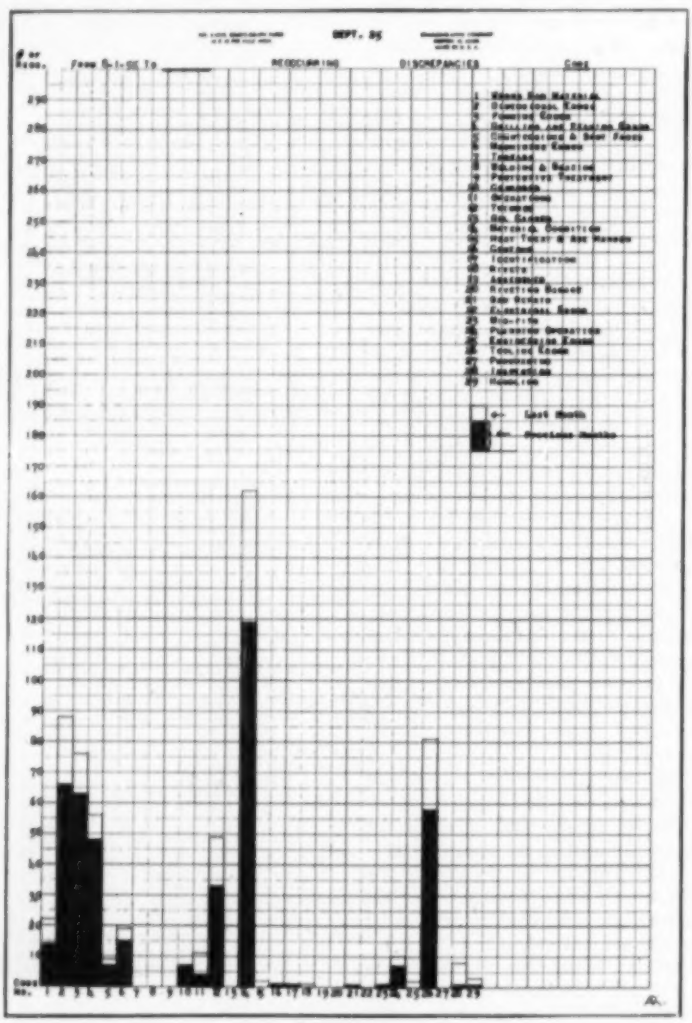


Figure 10

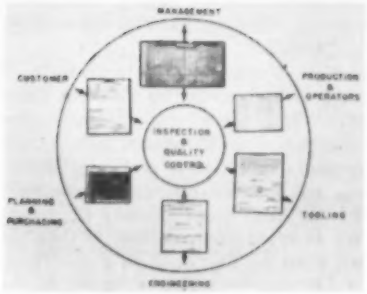


Figure 11—Coordination Improves Quality, Increases Production, Reduces Cost

used only by the shop personnel to identify material which they know is defective and do not wish to present to inspection. The items they reject are not entered in the tabulated report or charted with the other inspection rejections. They are accumulated with other scrap items in Salvage. In this way a quality incentive is created—a desire to check the work more closely.

Charts are sent to management monthly showing the trend in each department for rework, rejections and scrap. (See Fig. 5 and 6.)

We use special and psychological forms to induce corrective action on outstanding errors. (See Fig. 7, 8, and 9.)

The effectiveness of the system used and how much improvement is required is governed by applying the same method to the finished and delivered product.

Condition reports on the delivered product are summarized to analyze the customer's problems and reactions. Troublesome areas are traced in a similar, simple, economical manner.

We see what we have done
We see where we are going
We see where we can make
our best improvements

A quality control system must be coordinated with the related departments which have a responsible part of designing, building, and selling a quality product. The Quality Control Department must receive, analyze and disseminate the important facts. (See Fig. 10 and 11.) This can be accomplished by conservative, well-planned quality control techniques.

Statistical quality control is a universal tool in world-wide use for higher quality and lower costs, but we must watch the balance line between quality and costs. Our prime objective is to know simply and economically more about our job, our product, and our business through quality control.

The Application of Punch Card Methods in Materials Review

PAUL E. ALLEN

Beech Aircraft Corp., Wichita, Kans.

THE processes or procedures used within industry and government for guiding the mechanics of determining where troubles exist, what troubles are the most serious, where the greatest degree of corrective effort should be applied, and the methods of measuring the effectiveness of such corrective effort expended are very intriguing. We studied many systems for this purpose before arriving at the system which we now use at Beech Aircraft for locating our quality control and service trouble spots. Some phases of our systems are modified versions of other manufacturers' or governmental agencies' procedures and some phases are original at Beech.

Our basic reasoning behind our materials review system and our punch card use is as follows:

- we wanted a method of determining the frequency of recurrence of discrepancies in materials from all or any of the several Beech facilities or on materials from our vendors

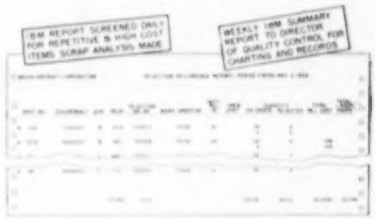

IBM REPORT SCREENED DAILY FOR REPETITIVE & HIGH COST ITEMS. SCRAP ANALYSIS MADE
WEEKLY IBM SUMMARY REPORT TO DIRECTOR OF QUALITY CONTROL FOR CHARTING AND RECORDS

Figure 1—Type of Data Record Obtained From IBM Cards

- we wanted a method of determining a comparative cost of scrap materials and the labor hours lost
- we wanted a means of establishing the volume of similar type rejection causes
- we wanted a means of determining if rejection trends varied between facilities, groups and projects
- we wanted a means of establishing complete rejection histories against a part number, etc.

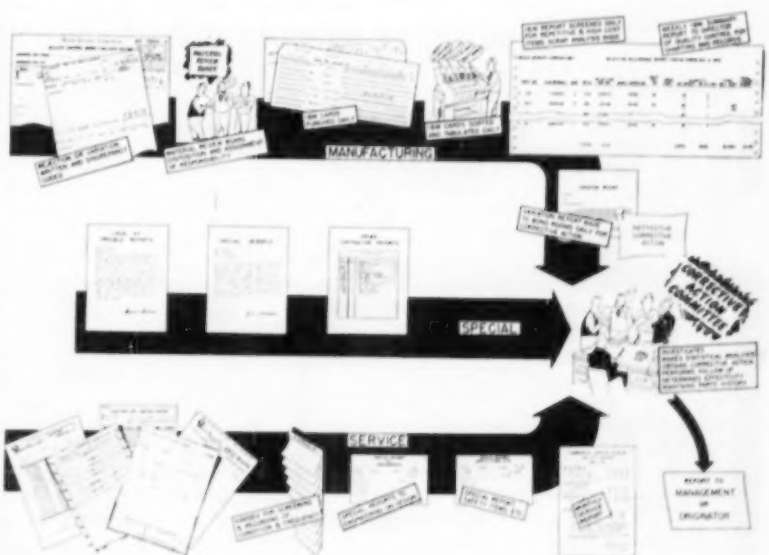
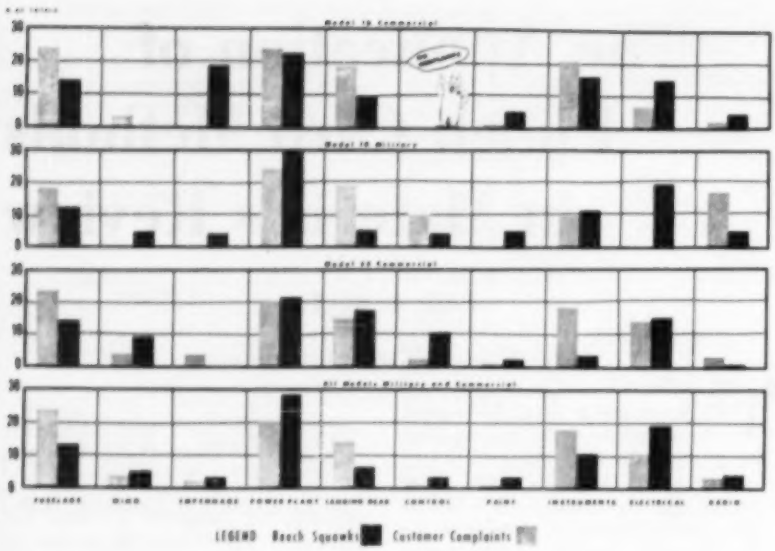
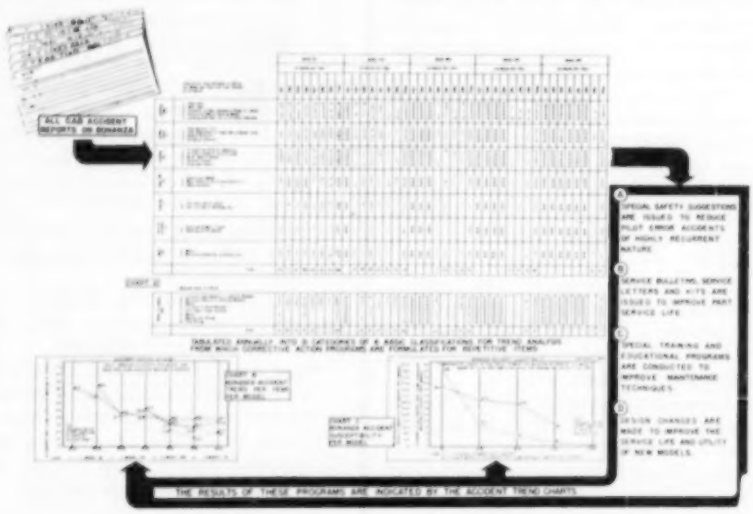


Figure 2—Corrective Action Flow Chart



Above, Figure 3—Final Acceptance Squawks and Customer Complaints



Right, Figure 4—Annual Accident Analysis

Below, Figure 5

ANALYSIS OF PRODUCT SERVICEABILITY
Beechcraft SERVICE LETTER
Beechcraft SERVICE BULLETIN
Beechcraft SERVICE DIVISION NEWS
CORRECTIVE ACTION COMMITTEE
SPECIAL TRAINING
OR NEW DESIGN IMPROVEMENT DUE TO ACTIVE KNOWLEDGE OF OUR PRODUCT SERVICEABILITY

- we wanted a means of determining rejected material disposition trends.

With a volume of rejections running as high as 26,000 a month from many facilities over a wide area, the selection of an automatic punch card system of tabulating and accumulating our desired information became an obvious "must" to our program. We adapted our program to IBM as we were familiar with its capabilities and it was available within our facility. The type of data record which we get from our punch cards on an IBM tape weekly is indicated in Fig. 1.

From this basic list and our daily IBM card screening, we establish our corrective action working list which is processed through our Corrective Action Committee as indicated in Fig. 2 for analysis, assignment to the responsible department, and follow-up to assure effectiveness of the corrective action. We feel that with the historical data made available through the mass tabulation of all rejections, all variations, and all service squawks on automatic punch cards, we have realized a greater degree of product control product analysis, and product improvement than would have been economically feasible, or even within the realm of possibility due to processing time, without the use of the automatic punch cards.

For example, we are able to compare customer squawks with inspection squawks in various areas of our products to help arrive at a balanced look at the product as indicated in Fig. 3. We are able to have a ready comparative analysis of our products' accident susceptibility per year per model in any number of general or specific categories as indicated in

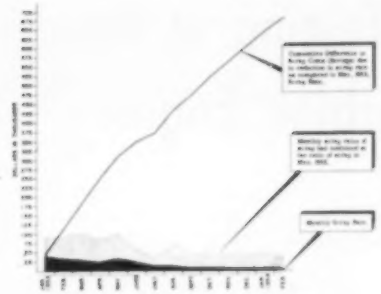


Figure 6—Monthly Scrap History

Fig. 4. We can readily accumulate and analyze service inspection results for establishing the most repetitive items to guide or influence our corrective action and training programs as indicated by Fig. 5.

One might easily question the advantages and disadvantages of such a broad program or system. However, the indicated results appear to be sufficiently impressive to justify, and even consider expanding, the program.

For example, the chart in Fig. 6 indicates that the reduced percentage of scrap effected during the first eight months of the system's operation represents a savings of over $677,000 in scrapped parts cost alone during 1953. In addition to this direct cost savings, our pieces of rejection paper have been reduced from a monthly average of 26,000 to less than 3,000 while our monthly dollar value of deliveries remains within 15 percent of the same level during this period. Assuming a minimum processing cost of $2 per piece of rejection paper, this reduction in volume of paper work would represent a savings of over $552,000 annually.

In addition to these savings, our quality control and engineering salvage man-hours expended per part produced have been reduced by about 85 percent in 15 months of the program as indicated by Fig. 7. The rejections and variations written as a percent of parts produced have been reduced by over 80 percent in 19 months of the program as indicated by the chart in Fig. 8.

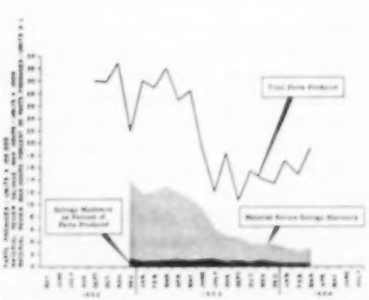


Figure 7—Salvage Manhours vs. Parts Produced

In order to be sure that we get the right balance between efficiency and customer satisfaction, we utilize our statistical data to assemble comparative product control picturegram charts such as that in Fig. 9 which shows:

- our fabricating shop rejection trend averages per month in the first phase
- our assembly line squawk averages per model per month in the second phase
- our maximum customer squawks for any one unit per month in the third phase (this is used as an indication of the uniformity of product control)
- the average customer squawks per model during 30, 60 and 120 days in service (this is used as an indication of our customer acceptance trend) in the fourth phase
- the average yearly warranty adjustment costs per model in the fifth phase.

It is noted that very impressive improvements in all phases are indicated by these charts.

Referring back to Chart C of Fig. 5, it can be seen that the accident susceptibility of each new model Bonanza has been better than the previous model and the over-all reduction in accident rate between the first and fourth model is about 50 percent.

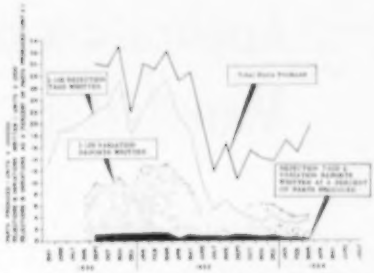


Figure 8—Rejections and Variations vs. Parts Produced

In Chart B of Fig. 5, it is noted that the Bonanzas built in 1947 have had an improving accident susceptibility record for each year in service, and after six years in service the rate is over 50 percent less than it was during the first year these planes were built. This is basically due to the service and educational programs which have been adopted to improve our products' utility. These programs have been guided by statistical records and analyses.

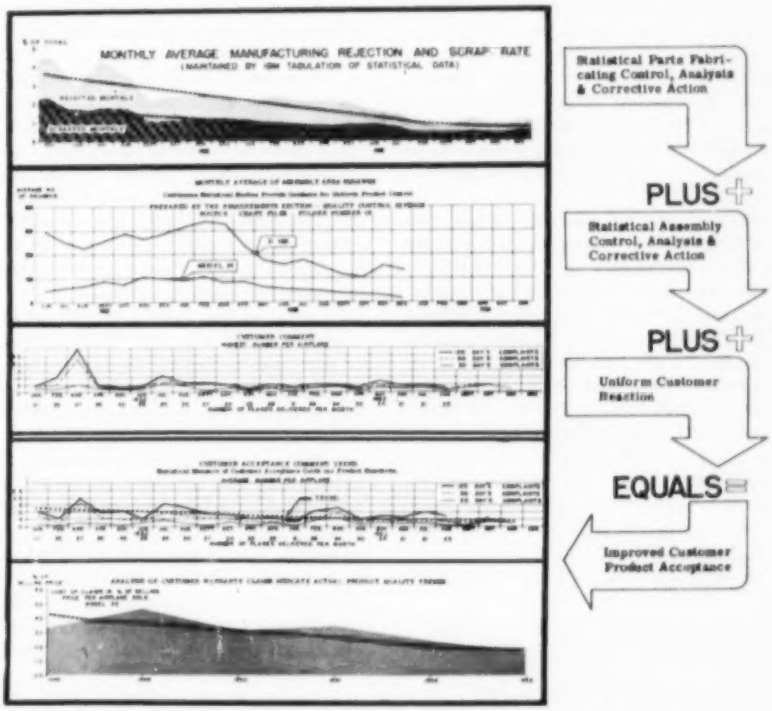

MONTHLY AVERAGE MANUFACTURING REJECTION AND SCRAP RATE
(MAINTAINED BY IBM TABULATION OF STATISTICAL DATA)
Statistical Parts Fabricating Control, Analysis & Corrective Action
PLUS
Statistical Assembly Control, Analysis & Corrective Action
PLUS
Uniform Customer Reaction
EQUALS
Improved Customer Product Acceptance

Figure 9—Balanced Product Control for Greater Customer Satisfaction

It is very doubtful that the above record of achievement would have been so complete or as effective if automatic punch cards had not been available or used. Our look into the future indicates an even greater use of automatic punch cards for inspection buy-off records, personnel evaluation, departmental cost records, as well as our material review and customer acceptance trend evaluations.

Application of Non-Destructive Testing in the Manufacture of Aviation Gas Turbine Engines*

FREDERICK W. ROHDE

Westinghouse Aircraft Gas Turbine Div., Kansas City, Mo.

THE subject of non-destructive testing methods in the field of aviation gas turbine manufacture, at first glance, appears to be something we take for granted as part of a normal day's work rather than something requiring additional time or thought. Actually, it is a major subject to be carefully studied and re-evaluated from month to month as conditions and developments change.

The term, "Non-Destructive Testing," is not a newly-coined phrase, but the actual understanding and frame of reference as we use the expression today has taken on a new concept in manufacturing and service areas.

Since quality control people are responsible to management for their actions and endeavor, this presentation attempts to show how the application of non-destructive testing methods can result in a better quality product with an ultimate saving in operating expenses. It will therefore be convenient to organize the presentation around the actual applications of non-destructive testing methods in the following four categories:

1. raw materials.
2. during manufacture.
3. during assembly and operation.
4. during the service life testing of the product.

Raw Materials Testing

The control of raw material involves a complexity of requirements. In order to effect the actual control of material used for aircraft purposes, we have to use any possible applicable science to determine its airworthiness. During the great industrial effort of World War II, we dealt chiefly with reciprocating engines. But since these had been in existence for a long time, our engineering knowledge was already well established and we were able to meet the requirements at that time with the application of known facts of non-destructive testing methods—(1) spectrographic analysis, (2) X-ray and radiography, (3) magnetic analysis, and (4) fluorescent penetrant analysis—plus destructive testing methods such as physical and chemical analysis, metallurigal hot and cold tests.

Since that time, a decade has passed and we are now working with entirely new kinds of engines—the axial flow gas turbines and related types. These new engines operate at speeds and temperatures that are three to four times greater than those of the reciprocal engine. This, of course, presents some very acute problems to the engineering departments in selecting, designating, and creating new types of materials and associated alloys, many of which today are non-magnetic. The results of these design efforts have been a new type of a non-destructive testing method, called the supersonic, ultrasonic, or sonic testing.

Several companies have played an influential role in the development of this new ultrasonic testing equipment: first, the Sperry Company and its contact inspection instruments such as the Reflectoscope; second, the Ladish fully-automatic Flaw Detector; third, the development and creation of the Immerscope, then the B-scan Flaw Detector by the Electro Circuits, Inc., Pasadena, California; fourth, the Simac version of the Ladish machine developed by the Sperry Company, and more recently the high resolving power Howry transducers.

We also begin to realize that the electronic age has given us many new ways of testing materials, which will produce better results for our efforts, and thereby help us to understand better the true conditions of the materials. Inasmuch as many questions are asked in regard to ultrasound and ultra-sonic testing, an explanation of some of the basic principles underlying these applications is in order.

Take the question, "What is ultrasound?" Briefly ultrasound is any *mechanical* vibration with a pitch, or frequency, so high that it is inaudible to the human ear. While human ears differ in the exact upper frequency they can detect, it is generally accepted that an audible sound comprises waves having a frequency less than 18,000 cps. Consequently ultrasound consists of the frequency spectrum beginning at 18,000 cps and extending clear up into the megacycle band. For some purposes, ultrasonic vibrations can be generated with whistles, sirens, tuning forks, or other familiar devices. For non-destructive test purposes, they are produced by an electronic oscillator device (which is very similar to a radio transmitter) to expand and contract a quartz crystal (the transducer), usually a million or more times a second.

The second basic question often asked is, "What is ultrasonic testing?" Such testing consists of using these electronically generated, high-frequency mechanical vibrations to locate flaws within various materials. This is made possible by the ability of most structual materials to echo, or reflect, ultrasound when there is an interruption, break, or inclusion in the material. For example, ultrasound will readily penetrate 30 feet of solid steel, yet it will be reflected back to its source by gas bubbles or foreign matter within the material, or by a different substance, such as air, on the far side of the material.

At this point, we should mention that it is highly important to any organization to subject its personnel controlling raw material for aircraft equipment to rigid training periods. Such personnel must not only be kept informed of any new developments in this field but also, above all, understand them throughly.

In many organizations we find modern ultrasonic testing equipment being used, but ineffectually. The results are not self-evident; quite often we have to study and substantiate the data, and train personnel to evaluate these data, in order to make proper decisions about the acceptance or rejection standards of the various types of material under test. Because considerable judgment is required, supervision has the responsibility for maintaining the equity in

*Presented at the 15th Annual Convention of the Society for Nondestructive Testing, Inc., Philadelphia, Pa., October 18, 1955.

test personnel in order that they may function properly in their respective assignments. In this effort we must be guided by process and inspection instructions based on reliable standards.

Now, the development of such instructions requires close coordination between the design, process, metallurgical engineering, manufacturing and quality control departments. Because the field is ever changing with improvements and new applications this coordination and cooperation must also be continuous. Therefore, we think, teach, work—and thereby improve our efforts by the adoption of new ideas and methods which move us toward the goal of better control of raw materials.

Testing During Manufacturing

So much for the first category. Now let us consider non-destructive testing methods used during manufacturing.

It is only natural to assume that during the first phase we have run the gauntlet of all known test methods in order to provide acceptable material to the manufacturing departments. We must also realize that in spite of these efforts there is still the possibility of running into defects during manufacturing and thereby the chance that we may have to reject material partially machined. Naturally since this involves a great loss of money and effort, our aim is to find as many of these defects as possible before such material enters the manufacturing cycle. In order to do this, we have the magnetic analysis and fluorescent penetrant analysis tests which help a great deal, and here we find that our solid forgings and bar stock are generally under excellent control. However, in the area of testing magnesium and aluminum castings the field is still wide open for detecting defects before starting such parts into the manufacturing stage. While the various types of X-ray methods and radiographs for detecting the flaws in magnesium and aluminum castings are an improvement over the first two methods, there is plenty of room in the field of non-destructive testing for future improvement. Actually since most castings permit the use of ultrasonic method, our greatest hope for testing and determining defects ahead of the manufacturing cycles lies here.

Another manufacturing problem concerns the control of sheet metal fabrication and in particular the welding of assemblies. Since the advent of aircraft gas turbines, we have developed numerous skills in this area of manufacturing. Electronic devices have been developed to control our spot and seam welding machines, but this control is still not positive enough to keep us from producing plastic welds, which are very dangerous. During inspection we introduce actual comparative weld samples at certain time intervals to assure us that the process is in control, but this is visual comparison and not sufficiently reliable. We are looking toward ultrasonics for further development of non-destructive testing to assure a sound seam or buttweld. Experiments are currently being conducted continually by many establishments, in order to find a better and less costly control of welds.

We have barely scratched the surface of sonic application in manufacturing and quality control. Responsible people should busy themselves and become very much interested in the great possibilities for future applications of ultrasonics. You may have read the article in the May 1955 issue of the *Reader's Digest* entitled "New Wonders of 'Silent Sound'", by Harland Manchester. It would be wise for those who are interested to read this article.

It goes beyond present testing applications and even points out the possibility of using ultrasonics for actual machining operations. With the newest invention of Dr. Howry of Denver, in which he uses a new type of transducer containing lithium sulphate crystals, the ultrasonic frequency is stepped up from the present range of approximately 500 Kc to around 8 Mc. This new ability to produce such a greater ultrasonic frequency may well be the start of a new era of using such type transducers for actual manufacturing and production. Engineers have already begun to conduct research in this field with the thought in mind to create ultrasonic broaching and drilling tools for high temperature steels. Such tools, if they can be developed at reasonable cost, lead us to hope that someday we can do away with the present expensive procurement and tooling using carbide steels and diamonds for cutting. It is believed that the possibilities in this field go far beyond our present comprehension. If drilling and broaching is possible, quite probably ultrasonic tools may also be developed for yet other machining operations. Only the future will reveal all the possibilities.

Assembly and Operation Tests

Normally, when we assemble parts to create an engine, we perform mostly functional testing of our accessories and completed engines. However, quite a bit of special test equipment has been designed during the last decade permitting all accessories to be individually tested to specification in order to determine the airworthiness of the article. We found, like many other manufacturers, that specialized, functional testing with special equipment saves considerable time in the final testing of a completely assembled engine. The final test of an engine will indicate the successful operation anyway, but at that time the malfunctioning of even the most simple accessory adds to the cost and penalty of running an engine on the test stand. This can amount to approximately $600 per hour, whereas an individual test for an accessory varies from $25 to $50 per hour. Therefore, during high production, cost can be enormous if malfunctioning occurs and no specialized, functional test equipment is available. Of course the initial expense for special test equipment is high, but the ultimate savings in money, schedule maintenance, and safety features of individual accessory testing are real benefits that no production setup should be without.

Outside of visual inspection with the aid of magnetic analysis and fluorescent particle inspection, no further non-destructive testing methods are applied in assembly or test, except when metallurgical search is made to investigate a possible defect by acid etching or other non-destructive methods.

Actually we look toward electronics for future help in developing new inspection tools in this area. The field is filled with many complex problems that need solving; one such phenomenon that has already presented itself is that of resonant oscillations. Many will recall the story of the Tacoma Narrows bridge a few years ago. It was finally decided that the frequency of the wind gusts through the narrows was so close to the "natural" frequency of the bridge that a condition of "resonance" was set up destroying the bridge. Ordinarily objects subjected to a vibrating or pulsating force will themselves be caused to vibrate, but generally only over a safely small distance, or amplitude. When the frequency of the force causing the object to vibrate, is the same or very close to the natural frequency of the object, then a condition of resonance is set up in which the amplitude of the vibrations induced in the object become so great that the object will usually be destroyed. There are numerous homely examples of resonance that

we see in everyday living—some good and some bad. If it weren't for the phenomonon of resonance we would have no radio or TV as we know it. When you push your youngster on a swing you unconsciously put resonance to work for you by pushing only at the end of the backswing. Caruso's ability to shatter a goblet by singing a single, sustained note to it is an example of destructive resonance.

It is this latter problem of destructive resonance with which we are faced. Earlier it was mentioned that present day turbine-type engines are operating at speeds three to four times greater than reciprocal engines. With the higher operating speeds it is being found that the frequencies of the vibration forces are approaching the "natural" frequencies of some of the parts and assemblies causing them to become defective or destroyed, and consequently seriously effecting the operation of the engine. It is apparent, therefore, that the efforts of our design engineering departments must be coordinated rapidly with test findings in order to improve the design and longevity of the part.

The test currently in use to determine the natural frequency of a part involves the use of an oscilloscope and a phenomenon known as a Lissajou pattern. First the part to be tested must be rigidly mounted in a fixture which will transmit vibrations but which will not ground out; i.e., the fixture must be "floating" in order to minimize its dampening effect on the vibrations. Pressure fits and the actual mounting must be carefully controlled to predetermined torque figures. Vibrations are then induced in the part under test by striking it with a mallet or other instrument, and if the mounting has been done properly these vibrations will pitch into the natural frequency of the part. A microphone placed within ⅛ in. of the part converts the vibrations from the part to an electrical signal at the same frequency, which is then amplified and applied to one of the deflection circuits of the oscilloscope. To the other deflection circuit is applied the output from an electronic oscillator whose frequency can be controlled and read from a calibrated dial. The resulting pattern on the tube face is a Lissajou figure. The frequency of the oscillator is changed until the pattern becomes an ellipse, at which time the oscillator frequency is exactly the same as the natural frequency of the part and can be read from the dial.

Obviously the natural frequencies of the various parts and assemblies as determined by this test are most useful to design because it enables them to keep the operating speeds of the engines below these values. While these tests are useful for determining the natural frequencies of parts, much still remains to be done in this area. Actually we should also be able to test for the natural frequencies of various assemblies, the completed engine, and indeed the actual airframe structures.

Service Life Tests

Finally, we have the field of actual operation and the ensuing service activities. Our servicemen consist mostly of practical service engineers who, in their daily effort, work in very close liaison with design engineering and quality control.

Reporting systems and communication are of very great importance in order to inform the manufacturing activities of difficulties in the field. A good system of reporting unsatisfactory operation in the field is a very essential part of non-destructive testing used by any modern quality control organization. The results of guiding such pertinent information to its proper source will aid greatly in combating difficult problems rapidly and efficiently.

Actual non-destructive testing methods used in the field, which give us quick results, are portable X-ray units, fluorescent penetrant, and magnetic analysis kits. Electronic and ultrasonic devices are essential aids in determining soundness and airworthiness of material, and are used more frequently in service operations than ever before, with excellent results.

Conclusion

In what has been said, we have tried to bring out certain of our problems today. There have been some very fundamental achievements, but there still remain problems in our practical endeavor. Closer and still closer coordination must follow between all people who are in the business of manufacturing aircraft engines.

Please realize that tremendous efforts are being made to control this type of work. It is felt that by such ardent and sincere effort, the ultrasonic application in this field will eventually give us correct answers.

There is a pertinent expression which was coined in the early days of our endeavor, and which is worthy of our profession: "Quality is never an accident. It is always the result of firm intention, sincere effort, intelligent direction, and skillful execution. It represents the wise choice of many alternatives and the cumulative experience of many craftsmen."

Bibliography

JOSEPH MOVSHIN, *Editor*

Assisted by the Editorial Committee, St. Louis Section, ASQC

APPLICATION—METALLURGICAL INDUSTRY

QUALITY CONTROL OF INVESTMENT CASTINGS, by Charles Yaker
(Precision Metal Molding, v. 14, Jan. 1956, p. 47)

This article outlines various control requirements which must be agreed upon with respect to aircraft quality investment castings. Unless the buyer and vendor can establish mutually agreed to and understood standards, it is difficult to reach a meeting of the minds in this matter.

APPLICATION—METAL WORKING

9TH ANNUAL QUALITY CONTROL FEATURE ISSUE
(Tooling and Production—v. XXII, n. 2, May, 1956)

The May, 1956 issue of "Tooling and Production" contains a series of articles on Statistical Quality Control and other Quality Control problems in the metal working industries. These are indicated below with short descriptions quoted from the Editorial Index of the May, 1956 issue of "Tooling and Production."

QUALITY CONTROL AND STANDARDIZATION, by John J.

Riordan (Department of Defense) page 6

"Standardization of Quality Control objectives will be a decided benefit to consumers and vendors by jointly delineating what constitutes acceptable quality."

DO YOU HAVE A UNIFIED Q-C PROGRAM? by Fay Carlson, "Warner Electric Brake & Clutch Company) page 74

"Mr. Carlson presents in detail the necessary obligations and cooperation required from management and plant personnel to make a Quality Control program a success."

STATISTICAL METHODS FOR SOLVING TOP MANAGEMENT'S PROBLEMS, by Edward C. Varnum, (Barber-Colman Company) page 79

"Because control charts and acceptance sampling tables are applicable to top management decision problems, the author gives case histories to demonstrate the solutions found to the problems under consideration."

Selected references in the Bibliography of *Industrial Quality Control* are obtained from the following sources:

The International Statistical Institute, *International Journal of Abstracts on Statistical Methods in Industry.*

ASQC's 10 YEARS—QUALITY CONTROL THEIR SPECIALTY, page 82

"An historical outline of the founding, objectives, and growth of the American Society for Quality Control is presented."

PLANT APPLICATION OF ACCEPTANCE SAMPLING BY ATTRIBUTES, by S. E. Peters, (The Dumore Company), page 83

"Determination of the most effective plan of sampling as practiced at Dumore is presented by Mr. Peters."

WHICH STANDARD DEVIATION? by Wendell H. Abbott, (General Electric Co.), page 86

"By example and demonstration Mr. Abbott illustrates the process of determining the standard deviation of a workpiece."

LARGER DIAMETERS — CLOSER TOLERANCES, by Loyd C. Bigelow, (Boice Gages, Inc.) page 89

"A gage manufacturer sets forth some of the conditions that have to be met when using indicator gages for close tolerance gaging of large diameter workpieces."

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QUALITY CONTROL OF CEMENTED CARBIDES, by W. C. Seitz and J. H. Powers, (Firth-Loach Metals, Inc.), page 93

"To insure production of high quality cemented carbides at Firth-Loach, extreme care is exercised in specifying, testing, and accepting raw materials."

SELLING MANAGEMENT A QUALITY CONTROL PROGRAM, (Part II), by Ray F. Engelgau, (Mueller Brass Co.), and Harmon S. Bayer, (Quality Control Consultant), page 95

"The authors outline an organized program to follow in establishing a system of Quality Control in the plant after management has given the go-ahead."

HOW DO WE MEASURE MACHINE CAPABILITY, by R. B. Nottingham, (Brush Electronics Co.), page 106

"Many of the frustrations which manufacturing personnel experience have their origin in a machine capability problem. Mr. Nottingham gives the procedure to follow in solving the problem."

QUALITY CONTROL OF JOB-LOT PRODUCTION, by Joseph Kalmanek, (Scully-Jones & Co.), page 118

"Originally it was thought that a Quality Control program could not be successful in a plant where over 50 percent of the annual production was short-run jobs of about 75 items per order. However, the program as developed is a success."

A STORY OF IN-PLANT TRAINING IN S.Q.C., by Robert M. Laforge, (University of Tennessee), page 160

"The advantages of in-plant statistical Quality Control training as against "short course" training are presented by the author."

A PLAN FOR GOOD PLANT HOUSEKEEPING, by C. P. Hawkins, (The Trundle Engineering Company), page 162

"Good housekeeping practices affect practically every variable element of cost of any producing company."

MANAGEMENT & PERSONNEL, GENERAL

LINEAR DECISION RULE FOR PRODUCTION AND EMPLOYMENT SCHEDULES, by C. C. Holt, F. Modigliani, H. A. Simon, (Carnegie Institute of Technology, Pittsburgh)

(Management Science—Oct. 1955, p. 1-30)

This article develops a model for the hiring and firing of workers based upon cost of indicated production and inventory levels. Basically, the cost for each month's activity is minimized in terms of the work force for a given predicted demand. Historical data was accumulated and indicated that considerable cost savings was indicated.

MISCELLANEOUS

WHAT SPECIFICATIONS MEAN TO YOU, by Hiram Brown, Company Chief Metallurgist, (Solar Aircraft Company, Des Moines, Iowa)

(Steel, The Metalworking Weekly, v. 138, n. 16, April, 1956, p. 92-95)

In contracting for the government, the problem of specifications is quite complicated. Contracts refer to specifications, blueprints, standards, etc. all of which in turn can refer to still more specifications. It is therefore necessary to be extremely careful both in bidding on and attempting to fulfill contracts where government specifications are involved. This article describes some of the problems, particularly with respect to the specifications of metal and the chemical and physical properties of metal. Ten precautions are described for those working with government contracts and specifications.

STATISTICS

ON THE JOINT DISTRIBUTION OF THE MEAN AND STANDARD DEVIATION, by B. M. Bennett (Annals of the Institute of Statistical Mathematics, v. VII, n. 1, p. 63)

ON THE THEORY OF SAMPLING WITH PROBABILITIES PROPORTIONATE TO GIVEN VALUES, by Sumiyasu Yamamoto

(Annals of the Institute of Statistical Mathematics, v. VII, n. 1, p. 25)

FROM THE SCRAP BOX

Statistical Quality Control in Engineering*

R. M. JACOBS
RCA, Camden, N. J.

The quality engineer's main tool is statistics in engineering. Quality control is a term applied to the process of controlling quality of product during the manufacturing processes. When does manufacturing start? Most of us will say, "when parts are made or when sub-assemblies are put together." However, experience has taught that manufacture starts on the engineer's sketch pad. It is felt that "quality" starts on the sketch pad because the engineer sets tolerances, and prescribes fits and finishes. The nature of his design determines the method of manufacture to be used.

Statistics in engineering helps the engineer to promote quality in the products he designs by a few very important techniques. The first is the technique of setting effective tolerances. The root-mean-square method is a system that very seldom fails. The most precise equipment can effectively utilize this system. Electrical and mechanical tolerances can be equally treated. This method assumes that production means have been well chosen and are in control (not producing more than 0.3 percent defective material).

The second technique, and just as important, is the analysis of test results. There are many phases of analysis, and a few examples will demonstrate the uses of the techniques indicated.

- **Testing Hypothesis**—Is the current failure rate significantly more or less than what was ex-

*This article originally appeared in RCA's *The Annotator*, Issue 21, Nov.-Dec. 1955.

pected or had occurred previously?

- **Correlation**—The varying of an environmental condition to determine the effect of an electrical characteristic.
- **Variance Analysis**—Two or more variables that effect a performance characteristic. The engineer can determine the effect of each variable on the characteristic and the effect of the interaction of the variables on the characteristic.
- **Significance Testing**—Which product, system, assembly, etc. is better than another, with a specific percentage of assurance that the decision is not in error.

A third technique that is very useful to a designer is the study of process capabilities which determine how much the designer can expect from a certain method of manufacture. Process capability studies of the equipment and the operations to be used can supply the engineer with valuable data on which method of manufacture is to be employed. For instance, if milling is the obvious operation, can the millers available produce the tolerance required? If not, the design might be changed to utilize a manufacturing method that can hold the tolerances. However, if the process is too accurate, more money might be spent than is necessary for the degree of accuracy required. These facts assist the designer in developing reliable high-quality low-cost equipment.

A fourth technique utilizes the principles of mathematical statistics to study failure reports, enabling the project engineer to concentrate efforts on the most expensive and troublesome faults. The technique will indicate trends and sequence of failures that are troublesome to the customer.

The last technique is a combination technique called the design of experiments. This may be used when an expensive destructive test is the only means of evaluating characteristics. A good statistical design may reduce the required quantity of the units to be destroyed by as much as 75 percent and still provide a sound basis for making decisions.

These and other techniques are used in engineering a quality product. Statistics in engineering has a valuable place in the list of engineering tools. Reliability and quality of product can be more easily achieved by the use of statistical techniques in engineering.

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Local Section News

"...BUT NOT FORGOTTEN"

ALBUQUERQUE On Apr. 12 R. E. Brooks, Tube Division, RCA, Harrison, N. J., gave a preview of a paper he was to present at the Washington Electronic Components Conference in May. Mr. Brooks' paper dealt with the design of subminiature tubes in meeting MIL-E-1 visual inspection requirements. A dinner business meeting was held at Leonard's Restaurant prior to the general meeting.

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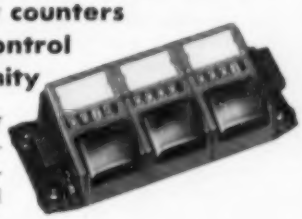

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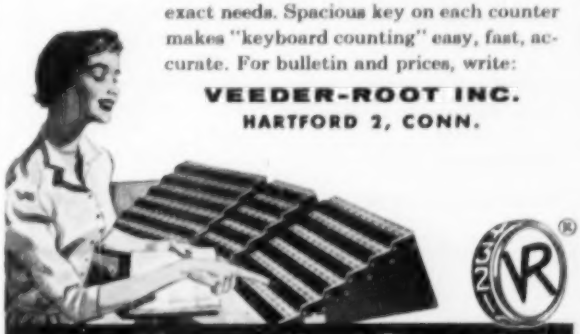

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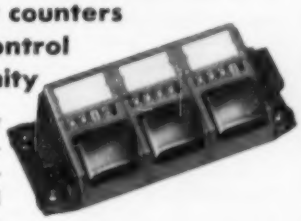

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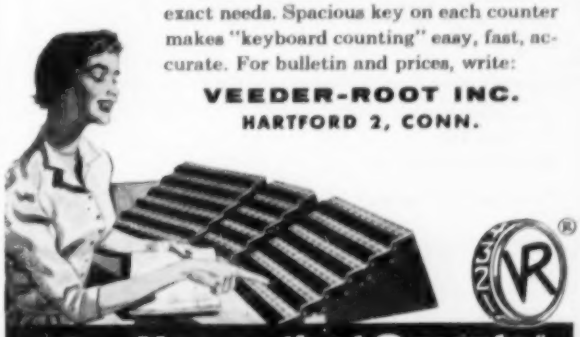

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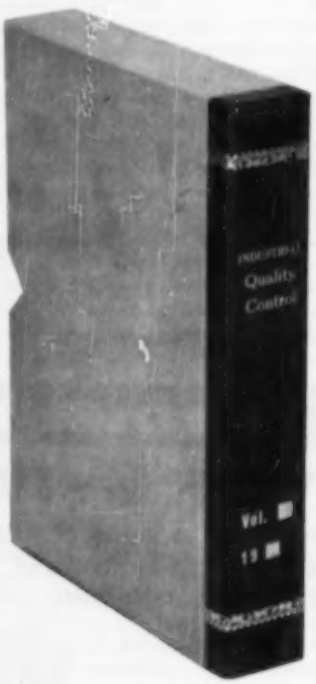

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national Harvester Co." Mr. Barrabee, who is general foreman of foundry inspection, supplemented his talk with slides. The general theme developed the possibilities of cost reduction through a quality improvement program.

LINCOLN The section enjoyed a joint meeting with ASTE and ASME at the Rome Hotel, Omaha, Neb., on Apr. 6. An outstanding display and lecture on "Civilization through tools" sponsored by the DoALL Co. made this meeting valuable to all three groups.

LOS ANGELES Dr. A. F. Cone of Sandia Corp. spoke of the role of quality control in the reliability of complex systems such as used by the Sandia Corp., before the April meeting.

MEMPHIS On Apr. 24 the section was guest of the Grace Chemical Co., Memphis. H. B. Green, assistant chief chemist, presented the quality control program at the laboratory. The visitation also included a tour of the laboratory facilities and the main plant.

MICHIGAN A Wolverine subsection meeting was held in East Lansing on Apr. 4. Kermit C. Brown from American Seating Co. in Grand Rapids was the speaker, his subject being "What makes a quality control program successful."

On Apr. 20 at the University of Michigan, Robert O. Muir from Lundberg Screw Products Co. of Lansing was guest speaker. His topic was entitled "Has quality control fallen short?"

MID-HUDSON The May meeting was held May 1 at the Hotel Governor Clinton, in Kingston, N. Y. This was a welcome change from our usual procedure of meeting in Poughkeepsie, especially to those who live and work in the Kingston area. The speaker for the evening was J. J. Riley, quality manager for The Barden Corp., Danbury, Conn., manufacturers of precision ball bearings. Mr. Riley's subject was "The application of quality control standard MIL-Q-5923 to the manufacture of precision ball bearings."

MINNESOTA A good turnout was had at the April meeting of the section to hear Gayle McElrath of the University of Minnesota speak on "Setting up a quality control department."

MILWAUKEE A double-barrelled program highlighted the Apr. 16 meeting held at the Stratford Hotel, Milwaukee. A one act play "Sampling inspection" by Bonnie Small was presented with an all-star cast of Milwaukee section members directed by Peter Gates. The educational training program consisted of a panel discussion of a series of new training aids on quality control acceptance procedures developed by a special committee of the electronics RETMA group.

NEW HAVEN On Apr. 10 the 2nd successful clinic meeting of the season was held at the North Haven Congregational Church. A delicious old fashioned church supper of chicken pot pie, apple pie, and all the fixings preceded the regular meeting. The clinic sessions were divided into two groups with topics and leaders as follows: "Statistical engineers" led by Jack Gillies and Herb Somers; "Trouble shooting and corrective action" led by Dave Albert and George Georgis.

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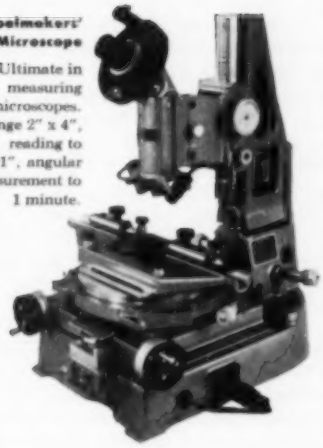

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NORTHEASTERN INDIANA Henry V. Dempsey, chief chemist for the Falstaff Brewing Co., Ft. Wayne, addressed the section at the Apr. 12 meeting using as his subject, "Quality control in multiple operations." The meeting was held in the hospitality room of the Falstaff Brewing Co. Mr. Dempsey served as chemist in Falstaff's central laboratory at St. Louis, Mo., before coming to Ft. Wayne. A graduate of Arkansas State College with a B. S. degree in chemistry, Mr. Dempsey has taken graduate studies at the Universities of Mississippi and Alabama. Before joining Falstaff he taught chemistry, biology and physics for three years in the Charleston, Mo. high school.

PHILADELPHIA E. C. Harrington, Jr., Monsanto Chemical Co., gave an inspiring talk to 45 members and guests of the section and the Philadelphia Chapter of the American Statistical Association. His topic, "New experimental designs—response surface experimentation," was eagerly received and questions from the audience indicated a need for this type of information.

PITTSBURGH "Quality control in the inspection of incoming steel shipments" was the subject of Guy J. Campbell's talk presented at the Apr. 24 meeting. Mr. Campbell, supervisor of quality control, Ternstedt Div., GMC, presented the aspects of the quality control of incoming steel shipments with respect to the properties needed for fabrication.

RHODE ISLAND Two fine subjects were presented to members of the section at the Apr. 19 meeting. William D. Miller, Anson Jewelry Co., discussed the "Practical use of quality control in jewelry manufacturing," and W. W. Kinney of Owens-Corning Fiberglas Corp. described the techniques he employed in establishing a "Quality incentive plan." A dinner at the Wayland Manor plus Cliff Kennedy's round table discussion on quality control preceded the regular meeting.

ROCHESTER The technical sub-group had an exceptionally fine turnout for Miss Besse B. Day, Department of the Navy, on Apr. 3. Her talk, "The principles of statistical planning," was well received as was evidenced by the lively discussion which followed the presentation.

The regular monthly dinner meeting was held on Apr. 17. Herbert Ashcroft, works manager of Bausch & Lomb Optical Co., Rochester, discussed the subject, "Training quality control engineers." His talk was very enlightening and supplemented talks given earlier in the year on the education, selection, and organization of technical men, engineers in particular. This rounded out a program to further discussion on these ever-present problems.

ST. LOUIS J. L. Coburn, Convair, Fort Worth, Texas, gave a most interesting discussion at the local section's Apr. 20 meeting on rework and scrap control made understandable to production people. He described in detail their record summary and reporting system for quality control and one of the items of particular interest was that even the mechanical brain will occasionally make mistakes in quoting data for quality control.

SCRANTON -WILKES-BARRE Our regular meeting was held at the YMCA Bldg., Scranton, on Apr. 18. The speaker for the evening was Elwood H. Rogge, assistant manager for the Leeds & Northrup Co., Philadelphia. Mr. Rooge gave

a very interesting talk on "Company education on the quality problem." He discussed the methods of determining a company's quality objective and means of achieving that goal. Following his talk a question and answer discussion was held, which was of great interest to all present.

SOUTH TEXAS One of the most attentive audiences of the year was present at the Apr. 11 meeting. The reason: O. R. Weaver, manager of quality control at the Phillips Petroleum Co., Rocket Fuel Div., at McGregor, Texas was the principal speaker. Mr. Weaver's subject, "Using attributes to establish variable inspection" was particularly thought-provoking; it was well presented and it kept the group leaning forward in their seats. The training section was well conducted by Joe Dickson of the Humble Oil and Refining Co., Baytown, Texas. Joe's subject was "An application of operation research to inventory control—a method to determine the optimum size of an inventory."

TOLEDO The highlight of the April meeting was a talk given by Dale Blair, chief of quality control of Continental Aviation, Toledo. The subject of his talk was "Basic principles of jet propulsion." The educational session was conducted by Dr. J. H. Toulouse, container division, Owens-Illinois, whose subject was "Correlation." The talks followed a dinner at Angelos.

The ASQC, TTC, ASME, AIIE, EST technical societies of Toledo sponsored a joint meeting at Toledo University. Dormen Theater was the place of the meeting and Dr. N. Maier talked on the topic of "Human engineering."

WESTERN MASSACHUSETTS At the Apr. 17 meeting attended by 31 members and 23 guests at the Sheraton Kimball Hotel in Springfield, we listened to Dorian Shainin, vice president of the Society and consultant for Rath & Strong, Inc., Boston. His talk was related to "Statistical methods for establishing specifications." Mr. Shainin explained what constitutes a complete specification. He emphasized that sources of difficulty in meeting specifications are relatively few and that the myriad of other elements were unimportant and vague. Some time was spent in discussing the manner in which Len Seder's multi-vari chart can greatly aid in finding the chief contributors to process variations.

WICHITA "Civilization through tools," a lecture exhibit showing how man's survival, development, and material welfare are dependent on tools, was given Apr. 11 at Curtis Intermediate School. A dinner was served in the school cafeteria preceding the lecture and the exhibit. The program was sponsored by the section along with the American Society for Metals and the ASTE.

WINDSOR A discussion of machine shop problems with regards to specification limits used at the Ford Motor Co., was the highlight of the section meeting held Apr. 5.

WINNEBAGO The April meeting was held at the Riverdale Country Club, Sheboygan, on Apr. 2. The speaker for the evening was S. J. Stellberg, director of quality control, John Deere Van Brunt Co. The title of his talk was "Statistical quality control applications in industry." A discussion period followed Mr. Stellberg's talk.

WORCESTER The meeting held on Apr. 12 was Ladies Night. The dinner-meeting was held at White Cliffs in Northboro, Mass. Wesley Reed, of the American Optical Co., Southboro, presented a very interesting talk and demonstration on early antique instruments. The ladies all received corsages and all present had an enjoyable evening.

YOUNGSTOWN The last regular technical meeting was held on Apr. 5 at the Astoria Cafe in Warren, Ohio. A fine steak dinner followed by a well presented talk by Welton Parker on "Quality control in electric wire and cable manufacture" proved to be a fitting climax to a well rounded out program for the 1955-56 season.

"... CAST THEIR SHADOWS BEFORE"

CHICAGO With the summer vacation season at hand, the section will discontinue its general activities till September. The officers and committee chairmen wish you and yours "A Happy Vacation"; see you in September.

COLUMBUS The annual business meeting of the section will be held on Wednesday, June 20, at 6:30 pm in the Colony Restaurant. Following the dinner we will have the officers and committee reports and installation of the new officers.

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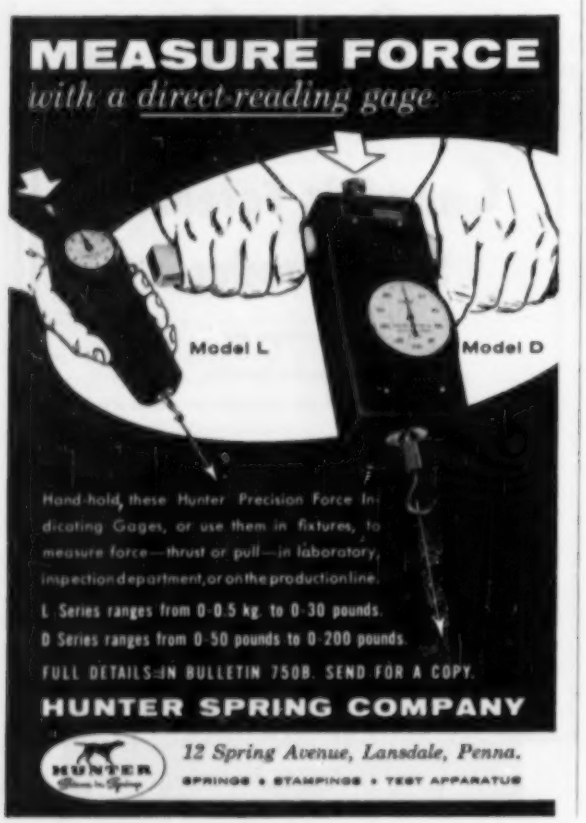
DANVILLE -SUNBURY During the summer months of June, July, and August, there will be no section meetings. Have an enjoyable summer, and the officers will be looking for you in September.

ERIE Most of us will vacation at this time (as if the Montreal tour wasn't a vacation). Some of the members are planning a baseball tour and are sure to engineer it. Other suggestions to keep section members in contact with each other for the summer include a picnic or fishing party at Lake Erie.

NEW HAVEN During the summer months, the executive committee will meet regularly each month to formulate plans for the coming 1956-57 season. These informal meetings, held at members homes, have proven to be very popular in the past.

SCRANTON -WILKES-BARRE All members of our section are looking forward with great interest to our June 20 meeting in Scranton. The speaker for this meeting will be Ralph Burt, Burt Associates, Springfield, Mass. His subject will be "Human relations in quality control."

TOLEDO The final spring meeting of the section will take place at Devils Lake at the summer home of A. B. McGehee, president of M & S Mfg. Co., Hudson, Mich. Mr. McGehee traditionally hosts this event and members of the section look forward each year to a grand social time. The 1956-57 officers are announced and installed at this meeting.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WESTERN MASSACHUSETTS In June, after the national convention, the new executives and committee chairmen for 1956-57 will meet to firmly establish the operations for the new season. Membership and advanced training will feature next season's activities.

This fall will find the section sponsoring an advance techniques training course. Experimental design, decision making, and linear programming will be featured.

"AS YE SOW . . ."

BOSTON The third annual 3-day management seminar sponsored by the section will be held June 19-20. This seminar is unique in presenting the philosophy of modern quality control to the levels of middle and upper management.

CELEBRATING A DECADE OF QUALITY PROGRESS OCTOBER 3-5 The New England sections of the Society announce that the Tenth Anniversary Conference is to be held at the Hotel Sheraton-Kimball in Springfield, Mass., on Oct. 3, 4, and 5. The conference theme is "Celebrating a decade of quality progress." For details write to: F. C. Hartwell, Secretary, c/o Peter J. Schweitzer, Inc.; Lee, Mass.

"FOR MANY ARE CALLED, BUT FEW ARE . . ."

BIRMINGHAM On Apr. 12 the following officers were elected to serve for the year 1956-57: president—Neil Zimmerman, Line Material Co., Birmingham, Ala.; vice president—Edwin Phelps, American Cast Iron Pipe Co.; Birmingham; vice president—Robert Fuller, Gulf States Paper Co., Tuscaloosa; secretary—Griffith Banker, U. S. Army Ordnance, Birmingham; treasurer—Hunter H. Roberts, Harbison-Walker Refractories, Fairfield.

BOSTON The annual election in April resulted in the election of the following section officers: chairman, Miss Frances Hermann, Arthur D. Little, Inc.; vice chairman, Harry Duane, Jr., G. E., WestLynn; treasurer, Miss Dorothea Looney, Polaroid Corp.; secretary, Martin W. Rogers, The National Co.

BUZZARDS BAY Officers elected for the 1956-57 season are: Mrs. Mary Lindenberg, chairman; John W. Ruggles, Jr., New Bedford Textile Co., vice chairman; Allan Fraser, Continental Screw Co., treasurer; Cecile Daley, Acushnet Process Co., secretary.

CORNING -ELMIRA The section is happy to announce that the following officers have been elected for the 1956-57 season: chairman, Andrew P. Stergion, manager of quality control, Corning Glass Works; vice chairman, Paul Tice, quality control supervisor, Eclipse Machine Div., Elmira, N. Y.; treasurer, E. B. Godsey, staff quality control dept., Corning Glass Works; secretary, Herman Albertine, quality control supervisor, Westinghouse Corp., Elmira.

DANVILLE -SUNBURY The section officers for the 1956-57 season are: chairman, J. Harold Backenstoe, Merck and Co.; vice chairman, George Simmons, Thompson Products, Inc.; secretary, James C. Rohland, Merck and Co.; treasurer, Burnett Tyson, Sylvania Electric Products, Inc.

DELAWARE The following officers have been elected to serve the Delaware section for the 1956-57 season: chairman, James W. Brown; vice chairman, Hillman C. Harris; secretary, Edmund L. Niedzielski; treasurer, LeRoy W. Miller. The section extends sincere congratulations to these new officers and pledges whole hearted support and cooperation during the coming season.

DENVER New officers elected for the coming year for the Denver section are as follows: chairman—Loren Straw, United Air Lines; vice chairman—Jack A. Schulz, Dow Chemical Co.; secretary-treasurer—George Custard, Denver Research Institute.

LOUISVILLE The new officers for next year have been elected. They are: chairman, Albert Osse, General Electric Co.; vice chairman, Allen D. Green, Jr., General Electric Co.; secretary, Carroll R. Ferguson, General Electric Co.; treasurer, Alan T. Thomas, Brown-Forman Distillers Corp.

MINNESOTA The new officers of the Minnesota section for the next year are: chairman—Harold Gulde, Minneapolis Honeywell Regulator Co.; vice chairman—Juel Enstad, General Mills, Mech. Div.; secretary, Mermond Olson, General Mills, Mech. Div.; treasurer, Grove Ruth, Minnesota Mining and Mfg. Co.

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LOOK TO CONTINENTAL

AS A SUBCONTRACTOR, WE CAN SUPPLY ALL NEEDS REQUIRED BY THE AIRCRAFT INDUSTRY. OUR TOOL SHOP, MACHINE SHOP, SHEET METAL FABRICATION AND ASSEMBLY, PROCESSING, LABORATORY, PACKAGING AND PRESERVATION FACILITIES ARE SUPPLIED WITH THE MOST MODERN EQUIPMENT WHICH IS OPERATED WITH COMPLETELY UP-TO-DATE TECHNIQUES. WE WILL SHORTLY BE IN A POSITION TO SUPPLY RESISTANCE WELDED METAL HONEYCOMB FABRICATED FROM THIN GAUGE STAINLESS STEEL AND OTHER SIMILAR HIGH HEAT RESISTANT MATERIALS.

Continental can always be depended on to manufacture and ship on schedule a consistant quality product for the aircraft industry from coast to coast.

Continental Can Company
Aircraft Plant
Coffeyville, Kansas

NEW HAVEN At the April meeting, the following officers were elected for the 1956-57 season: chairman, Gerald McVey, The Armstrong Rubber Co.; vice chairman, David Albert, Lycoming Div. of AVCO Mfg. Co.; secretary, Jack Bradshaw, Revere Corp. of America; treasurer, William Ajello.

NORTHEASTERN INDIANA The Northeastern Indiana section elected Don F. Hensel, Ft. Wayne Div. of the Dana Corp., chairman for the 1956-57 year succeeding M. G. Pugh of the General Electric Co. Other officers elected were: Harvey King, General Electric Co., vice chairman; Jack Made, Magnavox Co., secretary; Ed Bird, Dana Corp., treasurer.

PHILADELPHIA A tight race for chairman of the Philadelphia section culminated in a 22-21 election of current vice chairman S. Wirtschafter, I.T.E. Circuit Breaker Co. Other officers elected include: J. Melalek, Budd Co., vice chairman; Dr. M. Hamburg, University of Pennsylvania, secretary; J. Braverman, Frankford Arsenal, treasurer.

ROCHESTER New officers for the 1956-57 season are: president—Hubert C. Minard, Bausch and Lomb Optical Co.; vice president—Elmer Lalonde, Eastman Kodak Co.; secretary-treasurer—William H. Harrison, Bausch and Lomb Optical Co.

ST. LOUIS The new officers for the coming year have been elected. Those serving for the coming year will be Milton Weiss, president; Bill Von Meyer, vice president; Sam Huston, secretary; Simon Krasner, treasurer. Our many thanks to the past officers, vice president Milton Weiss, secretary Bill Von Meyer, and treasurer Sam Huston who have served so amiably under the excellent guidance of president Joe Movshin.

SOUTH TEXAS Election of officers for the 1956-57 year was part of the Apr. 11 meeting. Elected to serve are Joe Dickson, chairman; Bob Ellis, vice chairman; Graham McQuarrie, secretary; and Floyd Schemann, treasurer.

YOUNGSTOWN The officers of the Youngstown section for the 1956-57 season are: chairman—Chester R. Smith, supt. of quality control, Mallory-Sharon Corp.; vice chairman—Charles K. Cooper, QC supervisor, Packard Electric Div., GMC; secretary—Paul D. Belter, quality control engineer, Trumbul Lamp Works; treasurer—W. J. Cain, supt. quality control, Republic Steel Corp.

DIVISIONS

Administrative Applications

In its first year of existence, membership of the Administrative Applications Division has exceeded 560. Plans for its first conference are under way and will be announced soon. Members were pleased to receive a comprehensive bibliography of literature in the field, prepared by Dr. Grant Butterbaugh and his committee. They are presently preparing an annotated bibliography of articles dealing with administrative applications of probability control, that is, statistical techniques using the theory of probability in administrative field.

Management sub-division chairman Major General (ret.) Leslie E. Simon is now director of research and development for the Carborundum Co., Niagara Falls.

Henry Jacobson has left the Schaible Co. in Cincinnati and is now QC manager for the P. R. Mallory Co. in Indianapolis. His wife, Marjorie Sutherland, is resigning her position as QC director for the Clopay Corp. in Cincinnati to join Henry in Indianapolis.

Candidates for division officers are Howard L. Jones, chairman; Harmon S. Bayer, vice chairman; William F. Buhl, secretary; and Charles H. Joseph, Jr., treasurer.

MEMBERSHIP CORNER

Membership, Minnesota Section 1954-55

Without doubt this has been the finest membership year that the Minnesota section has ever experienced. We have a total membership of 218 as compared to 106 last year. This represents an increase of 106 percent, which is the greatest yearly increase our section has enjoyed. Our renewal rate is 91 percent this year as compared to 61 percent for the average of the two previous years. This year we have 54 companies and major divisions of companies represented in the section. This is an increase of 15 over the number included last year.

Our successful year can be attributed to two major causes:

1) An unusually good program of monthly meetings, special interest groups and educational program.

2) An organized sales force to sell the product that the Program and Education Committees have produced.

The membership committee was organized first to renew as many of the old members as possible; and second, to turn out the membership for our monthly meetings and thereby promote general interest in the Minnesota section. Accordingly, 38 men were organized into a committee with a representative in every company or major company division in which our section had members. These committeemen were given a manual covering sales points, a description of his duties, sample letters to prospects, a list of members in his area, etc. Once a month each man received a letter describing the progress of our campaign with additional sales points and a list of prospects in his area. Each of these prospects had previously received a letter inviting him to join. The committeeman then made a personal call on the prospect. The letter to the committeeman was so timed that it would serve as a meeting reminder and activate the committeeman to turning out the membership.

An active membership committee is a necessity to maintain membership. However, a good deal of our increase was due to our training course. Membership was included with course for people who paid for the training course. Many new members are gained in this way even though it raises a renewal problem in future years. Several of these people have renewed at this time and this is a net gain to the society.

By the yard its hard,
by the inch its a cinch.

Montreal Section

The Montreal section, formed in 1949 with a nucleus of only 15 members, grew so rapidly in the next few years that in 1953 a bid was made by the section for the 10th Annual National Convention. It was estimated, somewhat conservatively, that membership would be well above the 100 mark by 1956, a section well manned to play host to some 2,000 odd delegates. But, during the past three years the membership curve flattened alarmingly and we find ourselves today still four members short of the century mark. What is wrong?

Each year since 1951 a course in elementary statistical quality control has been held by our section. In that time approximately 150 persons have attended its classes but only a small percentage of these are today members of the national society. Our monthly meetings attract an average of ten guests, yet letters and follow-ups to these guests have borne little fruit.

It is our feeling that most of the larger manufacturing companies in the area are represented in our membership lists. Course and meeting attendance is bolstered by fellow workers from these companies but extra membership fees are not being authorized by their management. We must turn, therefore, to the hundreds of smaller companies not aware perhaps of our existence because of lack of adequate publicity in local papers and magazines.

Interest in quality control should be created in these smaller companies by the publicity to be given our 1956 Convention held this year in Montreal. We know that many new members can be found in Montreal. The Convention should bring many inquiries from these sources and we have set our target for 1957 at 125 members.

SIGNIFICANT DIFFERENCES

Tom W. Young, Birmingham section has been promoted to senior engineer of design and development of tires for the Akron Plant of Goodrich Tire and Rubber Co.

Frank McLaughlin of G.E. (Everett) and a member of the Boston section was recently promoted to a job on the quality control staff at General Electric Co. headquarters in Schenectady.

Gordon A. Olsen of the Columbus section has been promoted to superintendent of inspection, Ternstedt Div., GMC, Columbus, Ohio.

Dr. Robert Bechoffer of Cornell University, and education chairman of the Corning-Elmira section, is giving an 8-week, in-plant training course on the design of experiments at the Corning Glass Works, Corning, N. Y.

A branch plant of the Glen L. Martin Co. was recently opened near Denver. Hugh Campbell, manager of quality control for the new Denver plant, was welcomed as a guest by members of the Denver section at the April meeting.

Davis Gale, treasurer of the Mid-Hudson section, has been appointed director of quality control for the Bobrich Products Corp., Beacon, N. Y. Mr. Gale was previously quality control manager for Daystrom Electric Corp., Poughkeepsie, N. Y.

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The TRI-IND-X 260 KVP portable industrial X-Ray machine embodies advantages far surpassing any other in its field

Light . . . Transformer and tube head complete, 65 lbs . . . A one man carry. **Compact** . . . Tube head, 11" diameter by 36" . . . Can be operated in restricted space. End ground tube for convenience. **Powerful** . . . 260 KVP and 10 Ma in continuous operation. **Durable** . . . Tube head shock tested and approved according to MIL specifications.

Carefully engineered in each detail . . . Tube head perfectly balanced, greatly easing one man manipulation in close quarters; can be operated 400′ and more from power supply. Available with interchangeable tubes; either 35° or 360° cones of emission. Master control panel may be placed at any junction in the leads between power unit and transformer tube head.

New, completely self contained, self powered unit operates any place, anytime on its own gasoline . . . requires no outside connections.

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The Fostoria Div. of Auto-Lite recently announced that Fred D. Reardon, chief inspector at Auto-Lite and a member of the Toledo section, has been promoted to plant superintendent at the Fostoria plant.

The American Ceramic Society, upon recommendation of the fellows and action of the Board of Trustees recently honored J. H. Toulouse, Toledo section, by electing him a Fellow of ACS in recognition of productive scholarship in ceramic science and notable contribution to the ceramic art and industry. Dr. Toulouse was further honored by being selected as engineer of the year by the Toledo Technical Council.

The Western Massachusetts section, going outside of the manufacturing industry area this year, has been able to obtain several members this season from the "insurance business."

Since the section is to be host for the Tenth New England QC Conference, the section has pledged that 100 percent or 68 people from the section will attend the conference.

R. W. Watson, chairman of the Wichita section, was the guest speaker at the Independence, Kans., Lions Club on Apr. 17. Mr. Watson, manager of quality control at the Continental Can Co. plant in Coffeyville, talked on quality control and its benefits in all types of business and industry.

During C. E. Mason's association with the Wichita section, he has driven 14,800 miles in round trips from Coffeyville to Wichita, Kans. Mr. Mason is statistical quality control supervisor at Continental Can Co., Inc. plant no. 95, Coffeyville, and has been a regular attendant at section meetings, executive meetings, and committee meetings, over a period of four years. We of the Wichita section are quite proud of Mr. Mason's attendance record at meetings.

John C. Steinbrunn, 1955-56 program chairman of the Scranton–Wilkes–Barre section, has accepted the position of quality control supervisor for the Farnsworth Electric Co., Ft. Wayne, Ind.

George O. Hawley, quality assurance department, Sandia Corp., has been nominated to represent the Albuquerque section on the educational committee of the New Mexico Council of Scientific and Technical Societies. A long term, major objective of this committee is to provide active career counciling in the New Mexico school system along scientific and engineering lines.

For some time the officers and directors of the Rochester section felt there was a need for a complete library of books and publications on the subject of quality control that would be available to members of the local section. A committee under the chairmanship of Sigurd Swanson studied the problem. It was decided that the most efficient way to meet this need would be to donate $500 to the Rochester Public Library to expand their collection of publications on the subject of quality control. At the beginning of the program the library already had 42 books and periodicals concerning quality control and its related fields. Since October, 1955, the library, working with the Rochester section, has added 49 more books to this list. The end result is a good collection of materials on the subject of quality control and its related fields available to all the members of the section.

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... This device permits your audience to visualize the creation of a normal distribution pattern as well as the results of variables sampling. All beads are self-contained; nothing to drop out. Done in attractive mahagony complete with zipper carrying case.

ATTRIBUTE SAMPLING DEMONSTRATOR
... Complete unit consists of transparent plastic container, opaque colored beads, and wood paddles permitting easy identification of beads at a distance.

SIMULTATORS
... To demonstrate control chart plotting and shift of distribution pattern.

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NEW Bausch & Lomb
Measuring Magnifier

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7X HASTINGS
TRIPLE APLANATIC LENS

$21.00 includes magnifier, case and 1 scale

Make *quick* and *accurate* measurements of extremely small dimensions! Easy-to-use Measuring Magnifier measures radii, angles, diameters, decimal inches and decimal millimeters. One general-purpose and 3 separate scales permit accurate measurements. Magnifier without case or scales, $14. Magnifier, case and four scales, $36. Another precision optical instrument by Bausch & Lomb, available from selected industrial distributors.

WRITE *for complete details. Bausch & Lomb Optical Co., 30206 Lomb Park, Rochester 2, New York.*

BAUSCH & LOMB
SINCE 1853

What's New?

ROY A. WYLIE, *Editor*

When inquiring about "What's New?" items, please mention INDUSTRIAL QUALITY CONTROL

Micrometrical Manufacturing Co., 345 South Main St., Ann Arbor, Mich., announce the Profilometer Group II—a versatile, portable equipment combination for measuring surface roughness in the shop. This equipment measures more than 85 percent of all the varied surfaces produced by industry and measures all surfaces in many plants. It is priced at $1295.00. The equipment includes an Amplimeter, a Type LJ Tracer and a Mototrace for mechanical operation of the Tracer. The Tracer measures on ID's as small as ¼ inch, OD's as small as ⅛ inch, flats, tapers and narrow splines, and passes through a ¾ inch hole. The mototrace provides a smooth reciprocating tracing motion of 0.3 inches per second over any desired length of trace from 1/16 to 2¾ inches. The Amplimeter shows either arithmetical or r.m.s average roughness height and has six ranges with full-scale readings of three to 1000 microinches. Futher details are given in Bulletin LT17.

★ ★ ★

A new series of large diameter Bar Gages providing 0.0001 inches accuracy for inside or outside diameters as large as 36 inches has been announced by **Rimat Gage Co.**, 21 West Dayton St., Pasadena, Calif. Incorporating a design whereby special inspection requirements can be included quickly and economically, the new gages fill the gap between general purpose "stock" types and expensive special gages. If desired, infinite variability between nine and 36 inches can be obtained. Rimat can furnish gages with portable masters in a common carrying case for use by field inspectors. Complete sets answering needs of a few sizes over a wide range (common to oil-field, ordnance and guided missile industries) can be developed.

★ ★ ★

Federal Products Corp., 1144 Eddy St., Providence 1, R. I., has developed a new series of low maintenance, rugged, shockproof Dial Indicators. The gears, racks and pinions in the new indicators are all precision hardened. This imparts great durability to these vital parts and reduces the need for repairs to the vanishing point. Extensive tests both in the laboratory and in the shop have proven that the hardened gear movement can stand 50 percent more impact without damage than the conventional indicator movement. This not only minimizes maintenance costs but also makes a cushioned movement unnecessary. Internal friction has been further reduced from 16 to 25 percent. The net result is longer life, higher sensitivity and greater accuracy. Off-white and light green dials and fine-line graduations make easier and more accurate reading. Federal's Hardened Gear Dial Indicators are available in the four A.G.D. sizes—from 1 11/16 to 3⅝ inches in diameter as well as long-range and wetproof models. These indicators are identified by the suffix "-H" in the model number.

★ ★ ★

Petz-Emery Co., Pleasant Valley, N. Y., has added to its line of 24 models a newly designed dial indicator, model 21019, that will give accurate readings to within ten millionths of an inch. It is graduated in 50 millionths over a measuring range of 0.002 inches. Bezel size is 2¼ inches. The precision action of the indicator results from the simple construction and fully jeweled movements protected by the exclusive "Em-re 100 percent shock-proof system." The jewels cannot be damaged and the entire internal mechanism is virtually indestructible. The indicator is made to A.G.D. Group 2 mounting specifications. Non-glare bezels are available in black or other colors. Decimal graduations in black on glare-free white aluminum dials are standard. The entire unit is anti-magnetic.

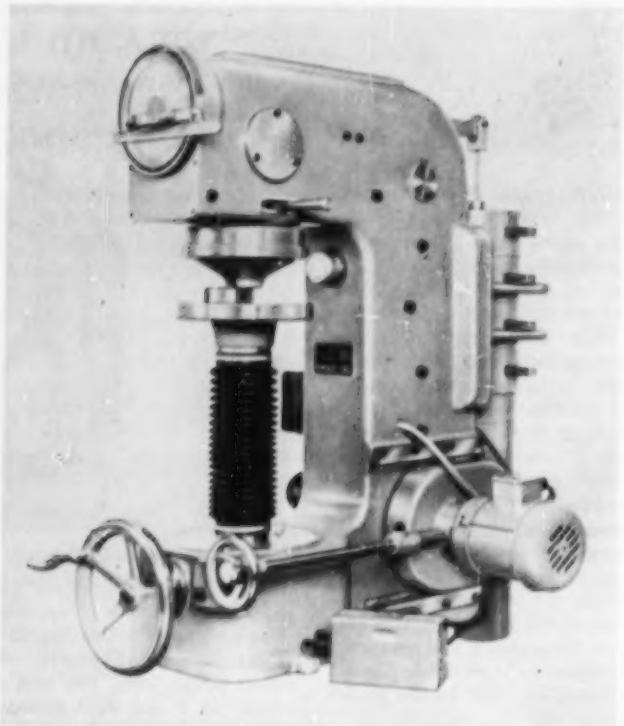
★ ★ ★

A new micrometer depth gage with a graduated base is announced by **The Lufkin Rule Co.**, Saginaw, Mich. Measurement of depths of holes, slots, projections, etc. can now be made at a specified distance from the edge of the work or hole because the base is graduated on one side, graduations are in 0.020 inches and extend to 2.4 inches both sides of zero, with zero located in the exact center of the base. The micrometer depth gage is available in ranges of three and six inches with lock nut or with lock nut and ratchet.

★ ★ ★

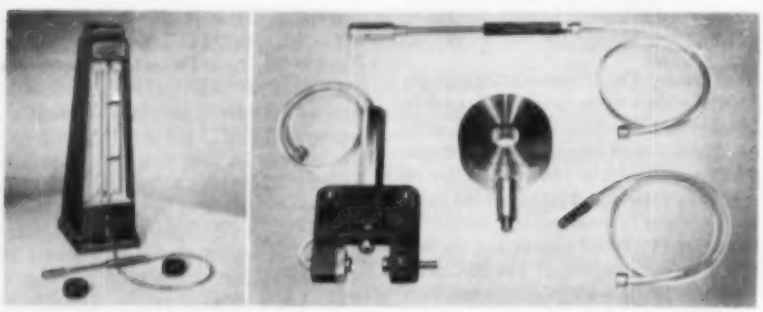
Available from **R. P. Cargille Laboratories, Inc.**, 117 Liberty St., New York 6, N. Y., is Detect-O-Pore Test Paper. The test paper provides a new means for making rapid tests on tin, nickel and chromium plating, etc. for pores. In use the test paper is moistened with a buffer solution made with a buffer powder furnished and then pressed down on the surface to be tested. Pores are shown by dark spots that develop on the paper. The test is quite sensitive. Detect-O-Pore test paper can also be used to indicate the metal under the plating because iron and steel give a greenish blue color, copper and brass give a brown color. The same test paper will also indicate pin holes in enamel, or other protective coatings over these metals and it shows minute rust spots on stainless steel. The paper is furnished in strips 50 ft. long by ½ inches wide in an opaque plastic dispenser.

★ ★ ★



Gries Industries, Inc., Testing Machines Division, New Rochelle 2, N. Y., have developed a new motorized reflex machine which indicates the diameter of Brinell impressions. Loads are applied by dead weight thru a motor drive, with cycles adjustable from five to 60 seconds. Various test loads are available from 120 kg for Vickers tests, to 3000 kg. Vertical clearance is 16 inches, horizontal reach 8 inches, net weight about 900 lbs. Operation is standard for 220 volt 3 phase. A built-in Carl Zeiss optical system automatically projects a greatly magnified image of the indentation on a ground glass screen. A device for indicating preset limits on the screen is provided so that the operator can use the machine like a "go, no-go" gage.

★ ★ ★



The newly formed Air Gage Division of **Dearborn Gage Co.,** 22038 Beech St., Dearborn, Mich., has introduced under the trade name "Dearbornaire" a new air gaging instrument incorporating several design and engineering features which are said to reduce down time to a minimum by eliminating interruptions for cleaning and service. Among the major design features which contribute to its trouble free continuity of operation are: (1) a higher rated pressure system, which combined with built-in circuit restrictions, assures a constant air pressure sufficient to keep the instrument self-purged of foreign impediments introduced by the air stream; (2) a new glass tube possessing a "characterized" internal taper which provides linear accuracy over the full extent of the calibrated scales. In addition this new tube design permits greater clearance between float and tube wall, thus eliminating the restrictive action of air borne oils and moisture and the need for frequent cleaning. The new Dearbornaire instruments are available as single or multiple column units in standard amplifications of 1250 to 1, 2500 to 1, and 5000 to 1 or any combination thereof. For all three amplifications zero is centered at midpoint on the calibrated scales for positive reading. Except for the float there are no moving parts or mechanical linkages to wear out and all basic components can be used interchangeably for all three amplifications. In addition to this new line of Dearbornaire instruments, Dearborn Gage Co. has also developed a complete line of air gaging elements designed for interchangeable use on all three standard amplifications. Included are air gage spindles, rings, snaps and cartridges. They are available in a wide range of sizes and with steel, chromium plated or carbide gaging surfaces.

★ ★ ★

The model 400 Transistorized Volt-ohmmeter, a light weight, portable instrument has been developed by the **New London Instrument Co., Inc.,** 78 Union St., New London, Conn. The model 400 features a wide range of voltage and resistance measurements which extend its usefulness to such fields as servo mechanisms, computers, and low level audio. In industrial applications it will measure the output of transducers, thermocouples and bridges. It will also handle signals encountered in magnetic modulators, square law crystals and photocells. The model 400 uses two junction transistors in a balanced circuit in order to provide a stable zero point. A fundamental internal calibrate circuit makes possible resetting of full scale sensitivity by means of a front panel control. Accuracy of the Voltohmme-

ter is two percent DC and three percent AC. The voltage ranges full scale at 200,000 ohms per volt DC and AC are from 0.03 to 1000 and the instrument is capable of reading one ohm midscale. The AC voltmeter is an averaging circuit to give lower waveform errors than a peak coding device. Total battery drain of one milliampere results in a battery life expectancy of 300 to 400 hours from low-cost standard cells.

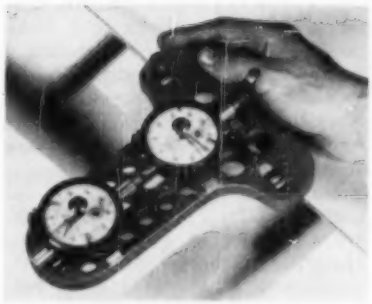
★ ★ ★

Black Light Corporation of America, San Gabriel, Calif., have announced a new special purpose ultra-violet lamp for better observation of low grade fluorescence, particularly in the critical areas of pale blue, light green and red. This long wave lamp, model BLF-6, utilizes a special tubular filter to cut down on visible light emission from the "black light" ultra-violet tube; thus less visible light strikes the object being examined. This results in an increase in contrast due to a more complete dropout of the non-fluorescent background. With its peak emission at 3660 angstrom units the BLF-6 is especially valuable for sanitation inspection, criminology, chromatography, oil analysis, and medical diagnosis, where subtle shadings in what otherwise would be termed "weak fluorescence" areas must be observed. Black-Ray model BLF-6 operates on 110-125 volt 50-60 cycle AC or may be used on batteries through a carrying case containing special battery adapter circuit.

★ ★ ★

The **Dayton Rogers Manufacturing Co.,** 2824-13th Avenue South, Minneapolis 7, Minn., have made available for free distribution a standard countersink gauge for calibrating both countersink tool and the finished countersink machined section of the work. Details are graduated for various angular standard countersinks for both machine and wood screws. The gauge is available free when requested on company letterhead.

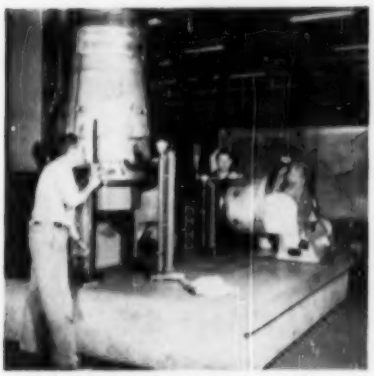
★ ★ ★



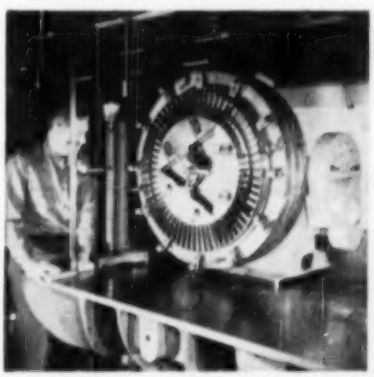
A new dial indicator gage for measuring the thickness of a sheet of glass very close to its edge is announced by **Federal Products Corp.,** 1144 Eddy St., Providence 1, R. I. This gage (Federal Model 259P-140) has two dial indicators, both equipped with special auxiliary magnetic hands. These magnetic hands are free to be pushed by the indicator pointer to its extreme position and remain there. One hand is used to obtain a maximum reading and the other a minimum. The gage rides along the glass on rollers and has a locating back stop to assure correct positioning for each measurement. The four top rollers are spaced so that measurements can be taken to the

ROTABS Beat Precision Inspection Costs...

This 24" ROTAB plus centering fixture cuts checking time for 11 dimensions on six vane segments from several hours to 5 minutes each.



Checking big jet engine assemblies is fast and simple on ROTABS (36" & 48"), eliminates costly fixtures made obsolete by engineering changes.



Seconds-of-arc precision allows quick, accurate inspection with low cost standard gages. Here 36" powered unit checks vane spacing.

For small parts inspection this 12" universal ROTAB minimizes setup and inspection time, does not require power for tilting and rotation.

For complete data on the optical precision readings you get with the ROTAB at the lowest cost, write:

MACHINE PRODUCTS CORP.

6771 East McNichols Road • Dept. G • Detroit 12, Mich.

end of the sheet and three point contact will be maintained for precise gaging. To obtain a reading, the operator sets the magnetic hands at zero, slides the gage on to the glass at one end and runs it quickly along the entire sheet. A glance at the magnetic hands tells him whether any spot along the edge of the glass is too thick or too thin. Although this gage was made for measuring glass it can be adapted to other sheet materials where thickness along the edge is a critical factor.

* * *

American Electronics, Inc., 655 West Washington Blvd., Los Angeles 15, Calif., have developed a highly sensitive, non-destructive, atomic energy leak detector for hermetically sealed objects. The Radiflo System provides a nominal sensitivity of one cc per 500 years and is ideally suited to the automation industry and custom testing among manufacturers, users, laboratories, etc., requiring products sealed to the highest standards of quality. Typical applications consist of hermetically sealed relays, evacuated metal bellows, special vacuum tubes, sealed switches, pressure and temperature controls, bourdon tubes, etc. The system may be used in any leak detection problem whether for positive or negative sealed pressures, and on a semi or fully automatic basis. The Radiflo System is economically adapted to mass production because large numbers of parts can be radiated or immersed and cleaned simultaneously. Over 50,000 parts may be tested per month on a single shift basis. The Radiflo System is available on a five year plan with option to purchase which includes full service, supervision and training and meets Federal requirements. Additional data may be obtained from the manufacturer.

* * *

NEW LITERATURE

A folder containing information and prices on the complete regular line of Lawley surface plates, angles, layout plates, straight edges, parallels and the new bonded composite construction surface plates is available from Lawley Granite Surface Plate Co., 2000 Wyoming Ave., Wyoming, Pa.

American Standards Assoc., 70 East 45th St., New York 17, N. Y., are making available a 94-page transcript of the meetings of the Sixth National Conference on Standards held in Washington, D.C. last October. Sponsored by the American Standards Association and the National Bureau of Standards, the meeting was the first of its kind ever held jointly by industry and a government agency. The 30 addresses point out the effectiveness of standards in saving money and increasing efficiency. Major segments of industry, Federal and state governments and the three military services are represented in the program presented. Price of the proceedings is $3.00 per copy.

A recently published 16-page booklet illustrating and describing many types of environmental test equipment manufactured by Murphy & Miller, Inc., 1326 South Michigan Ave., Chicago, Ill., will be mailed upon request. General performance and operating data on the equipment are included in the book.

The Harry W. Dietert Co., 9330 Roselawn Ave., Detroit 4, Mich., have a new catalog describing their line of equipment and accessories for accurately analyzing the amount of moisture in any solid, granular, liquid or semi-liquid material. Listed are Dietert Moisture Tellers, Speed Ovens, Speed Desiccators and accessory items such as balances, weights, sample pans and drying dishes.

A new 48-page illustrated catalog containing complete specifications and prices of the entire line of Dearborn Quality Controlled Gages pro-

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duced to AGD Standards is now available from Dearborn Gage Co., 22038 Beech St., Dearborn, Mich. Standard gages offered include: plain cylindrical ring gages, plain plug gages, progressive plug gages, reversible plug gages, tapered plain plug and ring gages, and master setting discs. In most cases the gages are available in steel, chromium plated, salvage by chromium plating and tungsten carbide, either sintered or flame plated.

CORRECTION NOTICE

The following four corrections should be noted in reference to J. Edward Jackson's article, "Quality Control Methods for Two Related Variables," which appeared in the January issue.

(1) page 6, column 1, line 9: should read 0.50 instead of 0.05.

(2) page 7, column 1, line 14: $F\alpha$

(3) page 7, column 1, 6th line from bottom: the expression..... should be replaced with $F_\alpha - \frac{(x - 264.32)(y - 471.48)}{80.45}$ should be enclosed in brackets.

(4) page 8, column 1, line 18: T_2 should be replaced with T^2.

Our apologies. — —

OUR EVER-GROWING FAMILY

With the addition of Cumberland, the total number of sections in the Society is now 91. The Society is proud to extend a most cordial welcome to the new section.

91—Cumberland (Dist. 5)

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Secretary-Treasurer: Paul M, Felker, Jr.
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Position Wanted as Quality Control and Development Manager or Consultant. Expert in establishing new program, or reducing cost and increasing effectiveness of existing program. Decisive trouble shooter; specialist in Vendor and Customer Contacts. One hundred hours public speaking and two hundred hours teaching and conference leading experience. Active in local ASQC Leadership. University degree. Salary open. Please reply to Box 12M1 at the above address.

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Bendix Missile Section is a major contractor in the U.S. Navy's guided missile program—a part of the "new look" in our defense plan. Our expanding program has many opportunities for quality control personnel: *Reliability Engineers, Quality Control Analysts, Statisticians,* and *Operations Research Specialists* will find challenging assignments in breaking through reliability barriers. Take time now to look into the opportunities which Bendix can offer you.

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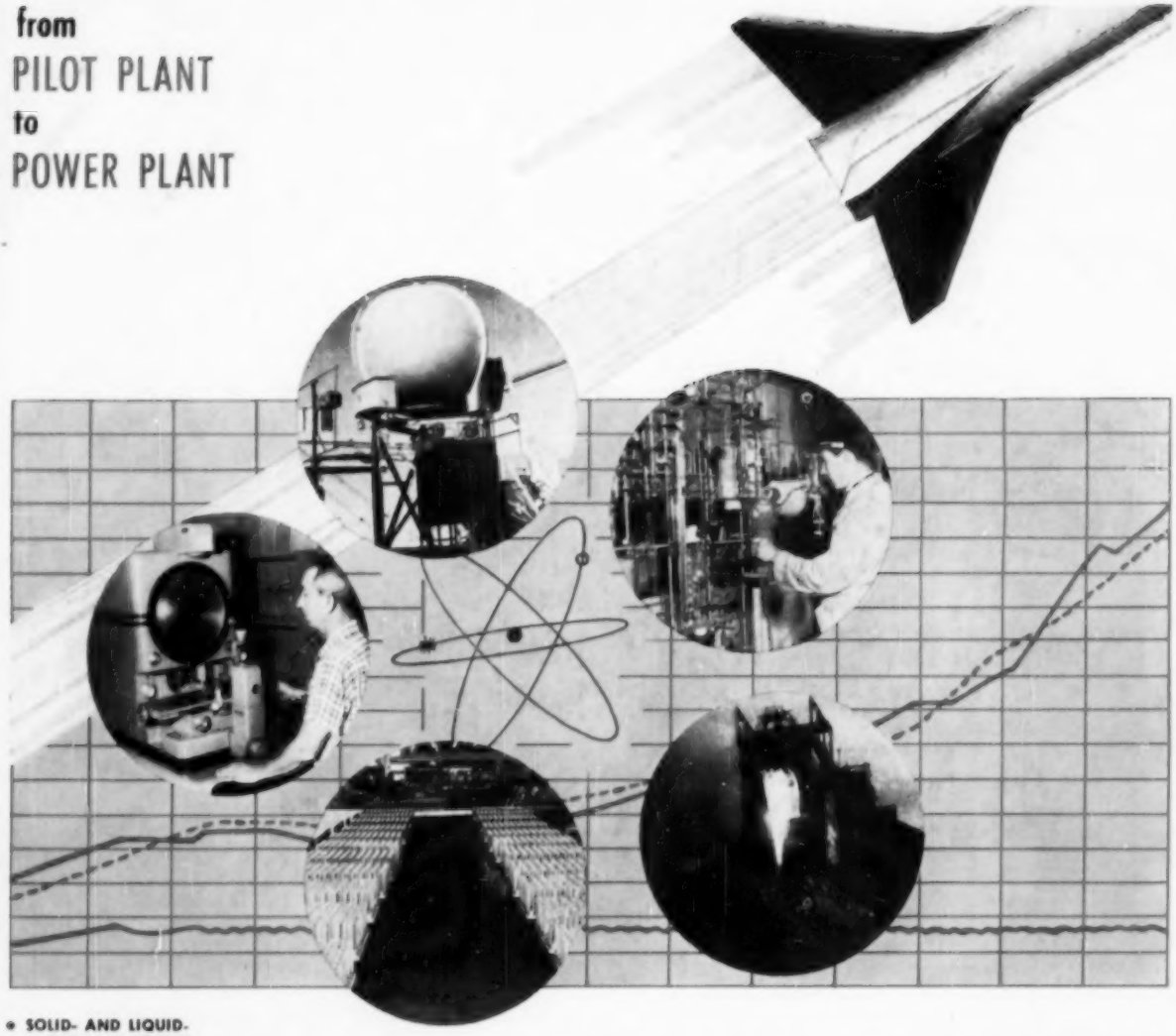

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